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QUICK FIRING GUNS.

THE application of the "quick firing" principle to guns which may fairly be classed as armor piercing will probably do more to govern the tactics of naval commanders in any war which may arise in the immediate—if not the distant—future than any other phase of production of warlike *materiel*. For service on shore it has been said that: "By the aid of quick firing guns and the position finder we are enabled to carry out the ideal system of defense, viz., few guns in dispersed emplacements concealed by natural features. The system has long been advocated by Sir Andrew Clarke, and it is difficult to see how any further opposition can consistently be offered to it."

For the protection of mine fields the quick firing gun would be invaluable; indeed, the authority we have just quoted considers the operations of sweeping, creeping, or countermining might be rendered absolutely impossible by the fire of quick firing guns. "The only reliable defense against an assailant's inshore squadron," continues Captain Stone, "will be the extensive employment of quick firing guns of sufficient caliber, not merely to annihilate landing or boarding parties, or to send a torpedo boat to the bottom, but equal to the task of putting a gunboat *hors de combat*, and either wrecking her or making it possible for the active harbor defense to capture her."

The use of shells charged with explosives more powerful than gunpowder has given additional importance to these projectiles of smaller natures, and with the increased development of higher explosives, a corresponding development of shell fire may be anticipated. This has already taken effect in the science of war ship design, and naval constructors are now looking with less favor on large unarmored surfaces, and indeed the older battle ships with comparatively thin armor, which a year or so ago were considered all but obsolete, are now considered as of some importance in view of the development of quick firing guns and high explosive shells.

The part which the Elswick firm has taken in the introduction of quick firing guns is well known. We give two views of a quick firing gun, of which the following is a description:

This weapon is the 4·7 in. simultaneous loading breech-loading gun, caliber 4·724 in., or 12 cm., firing a shell of 45 lb., with 12 lb. of P. or S. powder. The gun is entirely of steel, its total length 16 ft. 2 in.; length of bore, 40 calibers; and weight, 41 cwt.

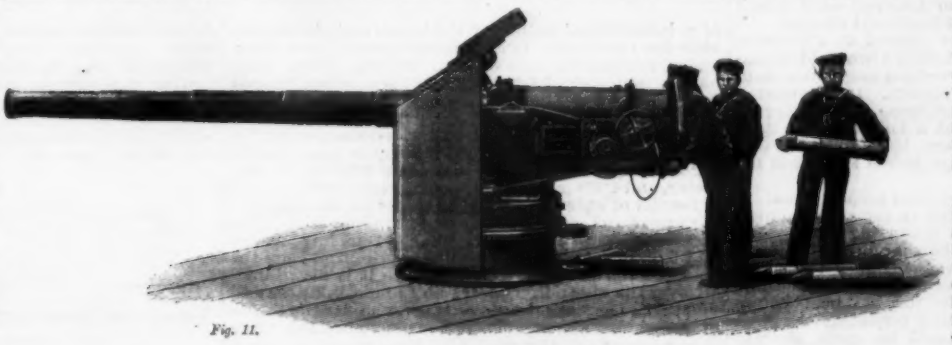


Fig. 11.

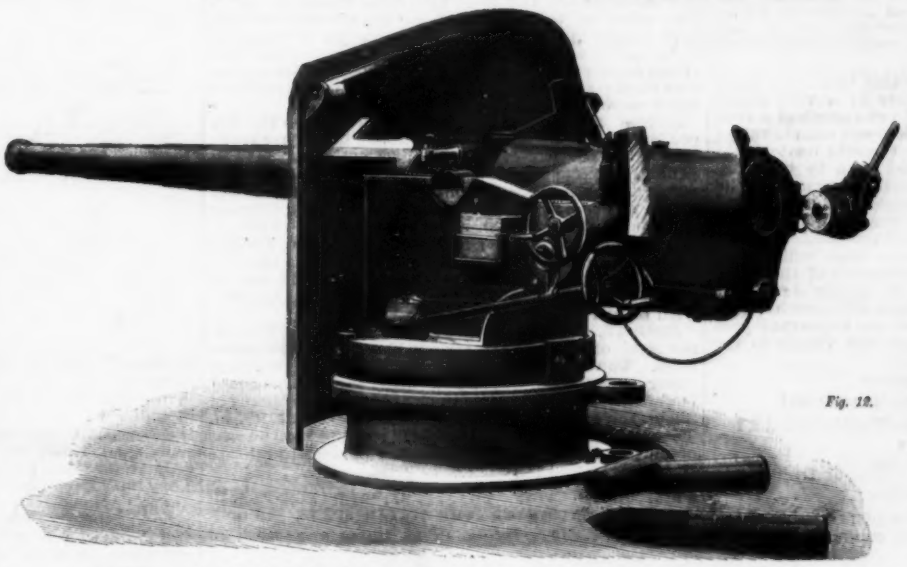


Fig. 12.

THE ARMSTRONG 4·7 INCH QUICK FIRING GUNS.

The breech is closed on the interrupted screw system, and to render the closing and opening more easy and rapid, the breech block is formed in two steps, both of which have portions of an interrupted screw on their surfaces, the threads on one step standing longitudinally opposite to the blank spaces on the other. This is well shown in Fig. 12, the breech block being there swung back. The breech block swings rapidly into place, and is secured by a small turning movement. The gun is fired by electricity. In the base of the cartridge case is screwed an electric primer, against which presses an insulated steel pin, carried in the axis of the breech block. This pin is in communication with the electric wires, which carry the current to fire the primer, only when the breech block is closed, and secured by turning the lever downward against the rear of the block. The circuit is closed, and the charge fired by pulling the trigger of a pistol handle, arranged in a convenient position close to the sights.

In case of the failure of the electrical firing gear, each gun is also fitted with a percussion lock; the electric primer in the base of the cartridge is replaced by a percussion primer of the same form, and the steel pin, which in the former case supplied the electrical contact, now serves as a firing needle. The percussion firing gear also has a safety appliance to prevent the charge being fired till the breech is closed and locked. In this manner all danger of accidental discharge is avoided, and complete security gained. The gun is mounted in a rocking slide, in which it can only move in the direction of recoil. Fixed to this rocking slide is a combined spring and hydraulic buffer arrangement, which serves both to check the recoil and also to run the gun out again after discharge. An arm projects downward from the breech of the gun, and is attached by a nut to the ram of the hydraulic recoil press. The gun itself has no trunnions, but slides in the rocking slide, to the extent of the recoil, which is only 9 in.

The action on firing is as follows: The gun slides back, within the rocking slide, the recoil being transmitted by the arm to the recoil press, where it is absorbed; the spring in the second cylinder is at the same time compressed.

As soon as the recoil is absorbed the spring begins to act, and pushes the gun back along the rocking slide to its first position. The lower part of the mounting is formed by a strong transverse steel plate or transom, which rigidly supports the mounting, and at the same time forms a substantial protection or shield to the base of the structure and the men working behind it. Above this is a lighter steel shield, covering the detachment from rifle fire, the upper portion being arranged to hinge back, so as to admit of a more extended view when using the gun at night.

The under carriage is carried on live rollers running on a bedplate, so as to insure great freedom of training, which is effected either by means of a shoulder piece rigidly connected to the under carriage or by a worm wheel training gear, worked by a hand wheel at the sighting or firing position. A clamp on the bedplate is provided, so as to fix the gun at any desired point of training. The elevation and depression of the gun require very little power, as the gun and working slide are accurately balanced on their trunnion bearings. The rack and pinion gear for this purpose is worked by an elevating hand wheel close to the training wheel, and thus also at the sighting or firing position.

This description applies equally to the quick firing guns and mountings of the larger natures. On account, however, of the increased weight of the ammunition, the cartridge and projectile are often handled separately.

The quick firing gun is an extension or, at any rate, the outcome of the smaller machine guns of the Hotchkiss, Nordenfelt, and Gardner type. The Hotchkiss are, however, now made up to 3·94 in. bore, and throw a projectile of 33 lb.

This class of gun is useful against torpedo boats and unarmored structures, but could hardly be used with effect upon any protection which could be dignified with the name of armor.

The ideal gun has been described as that which possesses high penetrative power and a capacity for firing shells with the most effective bursting charges, while it could, when required, be fired with great rapidity to repel a flotilla of attacking vessels.

These points are secured with the weapons we are now considering. With the 4·7 in., 5·5 in., and 6 in. guns the projectiles are 45 lb., 70 lb., and 100 lb., or even 120 lb. The rate of fire has been found in actual practice to be from six rounds per minute with the 6 in. gun to fourteen rounds per minute with the 4·7 in. gun. If we compare the rate of fire of these guns with that obtained from the ordinary breechloading guns in the service, we find that some experiments carried out on shipboard by the Admiralty gave ten rounds in 47 seconds from the 4·7 in. quick firing gun, while the 5 in. ordinary breechloader took 5 minutes 7 seconds to discharge the same number of rounds.

It is unnecessary to dwell on the advantages of rapidity of fire in action. It was this very feature which contributed so much in times past to British naval victories; although then the result was achieved by the superior hardihood and address of our seamen, who could serve their guns so much quicker than could their enemies.

In this epoch of mechanism, however, we must depend on the brains of our inventors rather than the muscles and nerves of our seamen to give like results; although we by no means wish to say that the day for nerve and muscle is past. Indeed, the value of cool and disciplined courage was never more apparent in the past than it will be in the next great naval war.

Hardly any superiority in *personnel* could compensate for the disadvantage in *materiel* of a gun requiring over five minutes to what another would accomplish in 47 seconds, and it is obvious, therefore, that we must have quick firing guns in spite of minor objections that may be raised against them, such as difficulties on account of smoke—when smokeless powder is not used—or in getting the ammunition to the gun with sufficient rapidity.

The Admiralty have not been slow to acknowledge the advantages of the new principle, and large orders for the navy for 4·7 in. and 6 in. guns have been given to the Messrs. Armstrong, the results of which are very plainly visible just now in the Elswick shops.

We have already described the mechanism of this gun, but there are some points in the design put forward by the makers to which attention may be called. By the interrupted screw system of breech closing two advantages are secured. First, the action of opening and closing the breech is much simplified, as the breech piece need not be withdrawn before hinging away; and secondly, the coned shape of the breech screw enables it to take hold, not only of the inner surface of the metal of breech piece or jacket, but also distributes the engagement, and therefore the strain and support, throughout a considerable thickness of the gun.

The breech screw is further arranged so that the threads of the smaller end of the cone correspond longitudinally with the interrupted spaces of the larger end, and *vice versa*, so that the strain and support are also distributed throughout the entire circumference of the breech screw, instead of, as formerly, half the circumference being lost by the interrupted spaces. In the mounting the labor of training and elevating is reduced to a minimum. A shoulder crutch and a pistol trigger is provided, and the piece can be handled by a single man with the same ease as the small Hotchkiss 6-pounder.

The recoil is so arranged that the man aiming can alter the position of the gun up to the very instant of firing, and also keep control of the gun working and sighting gear during the actual discharge, or throughout any number of rounds. Naval officers will not be slow to appreciate the advantage secured by this arrangement under the varying conditions of actions at sea.

The carriage allows the gun to recoil always in the line of fire, and the fixings and deck are thus to a large extent relieved of the ordinary recoil strains. After discharge the gun returns instantly and automatically to firing position. A substantial shield of steel, 4½ in. thick, is provided in front, and protection is thus given to the men serving the gun.

In the ammunition the principle of the ordinary rifle cartridge has been extended to these guns; the projectile and powder charge forming only one piece. The powder is put into a solid-drawn brass cartridge, in the

mouth of which the projectile is fixed, so that the whole can be handled together. A great saving of time and labor is thus effected, and the incidental advantages of increased safety, and the immunity of the powder from climatic deterioration, are also secured. To the fact of the projectile and charge being thus placed in the gun at the same time is due the title of "simultaneous loading" which has been applied to these guns. To the improvement in the ammunition the quick rate of firing is very largely to be attributed. The solid-drawn cartridge cases, owing to their great size, have presented difficulties in manufacture, but these have been now surmounted, and it is found in practice that they can be fired as many as ten times over without need of reforming.

In apportioning the ammunition for these guns, penetrating shell will constitute a very large proportion of the whole equipment.

Side by side with the improvement in the guns and mountings have gone new discoveries and developments of powder. The Chilworth Powder Company are now manufacturing a powder specially designed for use in these guns. It is practically smokeless; an inestimable advantage where rapid firing is an essential, and the hanging smoke which makes good aiming impossible is thus almost entirely avoided. The charge of this Chilworth powder is very much less than that of black prismatic required to produce the same effects. The pressures obtained with it are very uniform, and the velocities very high, ranging up to 2,450 ft. or 2,500 ft. per second.

One of the principal reasons that led to so large an employment of quick firing guns in naval services was no doubt the necessity of being able to cope instantly and effectually with the attack of torpedo boats. The very high rate of speed possessed by the modern torpedo boat, while increasing its powers of offense, has at the same time diminished the risk of its being hit. It not only remains a much shorter time exposed to fire when making its attack, but its rapid motion necessitates a great alteration of aim between each round fired at it, and a corresponding likelihood of error.

Suppose a torpedo boat to be sighted at a distance of 1,500 yards by a war vessel having a broadside armament of three service 5 in. breechloading guns, each capable of firing two rounds a minute. It is estimated that the torpedo boat could not hope to discharge a torpedo with much certainty at a longer range than 200 yards; and would, therefore, have to traverse a distance of 1,300 yards under fire before she could begin the attack.

Assuming the speed of a first-class torpedo boat to be twenty knots an hour, which is certainly a high figure, the time occupied in traversing 1,300 yards would be, roughly speaking, two minutes. The war vessel, therefore, armed with a broadside of three 5 in. guns, each firing two rounds per minute, would be able to discharge twelve shots at the torpedo boat before there was a chance of her being torpeded. If, however, in lieu of the three service 5 in. guns, she was armed with three of the improved Armstrong 4·7 in. 45-pounders, she could in the same time fire no less than seventy-two shots, each gun being capable of firing twelve shots a minute.

Besides the advantage of being able to fire six times as often, there is the collateral one of a very slight alteration of aim being required in one case and a very considerable one in the other. Between each round of the 5 in. breechloading gun, the torpedo boat would move 340 yards, and the aim would have to be correspondingly altered; while between the rounds of the 45-pounder gun she would only move thirty yards, and a very slight alteration would be required, and a successful shot could thus be instantly repeated.

But although it was the torpedo boat which first gave such an impetus to the introduction of the quick firing gun, the weapon has been so largely developed in the progress of time that it now holds a much higher position, and cannot fail to play an important part in encounters between important war vessels in the future.—*Engineering.*

[Continued from SUPPLEMENT, No. 728, page 11565.]

THE CHANNEL BRIDGE—PRELIMINARY DESIGNS.*

By Messrs. SCHNEIDER & Co., Creusot Iron Works and H. HERSENT.

Piers.—The metal portion of the piers comprises two columns of 34·900 m. high. Each column is formed of two cylindrical cores having a common axis, and a diameter of 4·600 m. and 6·400 m. respectively; twelve such cores arranged in a precisely vertical plane serve to connect the others, and by their prolongation form external and internal stiffeners. The interior stiffeners have a free space of 3 m., which is invariable throughout the height of the column. The outer stiffeners give the body of the pier an apparent diameter of 8 m., which gradually increases to 12 m. toward the base. The inner cylindrical core is provided with a prolongation of 14 m., forming an anchoring tube of 4 m. in diameter, but as it would be insufficient in case of a longitudinal action of the wind, and also to provide for expansion, twelve anchor bolts have been added, forming the bed of each column. These bolts have a diameter of 0·250 m., and their action extends over a height of 14 m. of masonry. The two columns of the same pier are connected by braces which enable them generally to resist the transverse action of the wind. The piers terminate at the top in ledges carrying the balustrade. A circular plate 6·200 m. in diameter, and 1·400 m. in height, covers each column, and is formed of sheet iron, serving to receive the supporting apparatus with a fixed or expanding foot. The expansion gear comprises six rails, 0·600 m. in diameter and 3 m. in length. The load is transmitted from the floors to the piers by sockets, hence it is distributed all over the sheet iron plates and angle irons, braced together so as to prevent overturning under the action of the wind. The columns of the piers are fixed, while the columns of the next pier have expansion gear. The effect of the expansion or the contraction of a floor results in a corresponding reduction or augmentation of the play between the overhanging portions of the cantilever and the ends of the independent span. The span rests on one side upon fixed supports, on the other on rolling gear.

Section 2. *The Spans of* 200 *m. and* 350 *m.*—The upper level of the rails is 72 m. above low water level. The lower portion of the bridge is supposed to be at 62·680 m. above the low water level throughout the whole extent of the spans of 200 m., while in the center of the spans of 350 m. the height above the low water level is 66·497 m. The whole of the spans of 200 m. and 300 m. being similar to the spans of 300 m. and 500 m., it will suffice, after what has been said in the preceding paragraph, to refer to sheets 10, 11, 12, and 13 of the plans to comprehend the arrangement adopted with regard to this type of spans.

Section 3. *The Spans of* 100 *m. and* 250 *m.*—The upper level of the rails is always 72 m. above low water level. The lower portion of the bridge is quoted as being at 63·780 m. above low water level throughout the spans of 100 m., while in the center of the spans of 250 m. the height above the low water level is 66·497 m. To comprehend the arrangement adopted in the case of this latter type of span, it is sufficient to refer to sheets 14, 15, and 16.

VII.—CONSTRUCTION, TRANSPORT, AND PUTTING IN POSITION OF THE METAL SPANS.

Section 1. *Description.*—The important work of putting down a complete fitting-up plant will have to be carried out upon the coast in the vicinity of the abutment of the bridge. The small port of Ambleteuse, sufficiently sheltered from the winds of the offing and the effects of breakers, seems to be best adapted for this plant, which, as already described, consists of two quays provided with suitably arranged jetties. These are intended to sustain the weight of the whole metal framework, and therefore constitute an essential part of the plant. The quays are to connect these jetties. They are supplemented by a channel of sufficient width and depth to allow each loaded span to wait for a favorable moment to be placed on the piers by means of tugs. Upon the quays scaffolding will be erected, supplied with powerful and improved machinery, such as cranes, steam winches, and hydraulic lifting machines. The various parts of the bridge will reach the working yard in as complete a condition as possible. A greater or less number of works may be applied to to manufacture these different parts, in order to avoid the necessity of rapidly calling into existence a regular industrial town on a desert part of the coast, and thus obviate any disorder that may result from so doing, either while the works are proceeding or after their abrupt completion. The fitting together of all the pieces can be mainly done in the work yards, as regards the central spans and the overhanging cantilever arms. Once fitted up, each span will have to be freed from all supports except those upon which it is supposed finally to rest. They must then be sufficiently shifted along the jetties to enable them to be placed on the barges provided for carrying them to their ultimate position—see Figs. 17 and 18. The power required for hoisting the bridge is not such as to be above the capacity of hydraulic cranes. Let us, in fact, consider the case in which the difficulty appears to be most serious, namely, that of the central span of 300 m., with 50 m. in overhanging portions on either side, weighing 9,580 tons. Supposing the coefficient of friction to be 0·10, it will be seen that the effort necessary will only amount to 958 tons. Particular attention is to be paid to the arrangement of the slides. As the bridge, indeed, must be able to remain upon the scaffoldings for a certain time, means must be provided for turning it round. The supporting surface is to be formed by the base of a cone carrying the turning socket. Thus, in the case of the heaviest span, a surface of 15 square meters will be obtained for 4,790 tons, which amounts to 32 kilogrammes per square centimeter.

The slides will have to be strongly fixed to the masonry. To avoid their breaking under the strain they will have to undergo, they must be able to support about 500 tons at the transverse section, their width being 2·50 m. They evidently must be about 20 mm. thick. They will rest upon wooden crossbars, lest, in consequence of some difficulty in the execution of the work, an excessive pressure per unit of surface should

FIG. 15. *Central Span and Cantilever Arms*

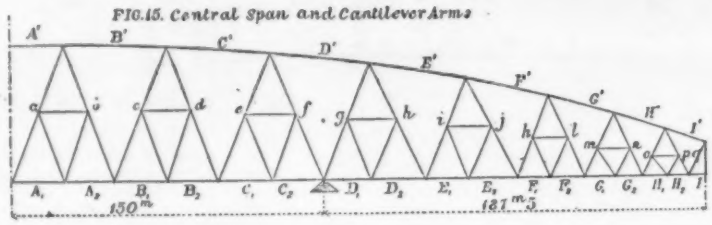
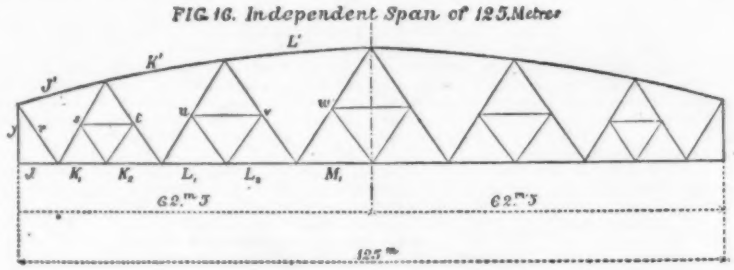


FIG. 16. *Independent Span of 125 Metres*



FIGS. 14.

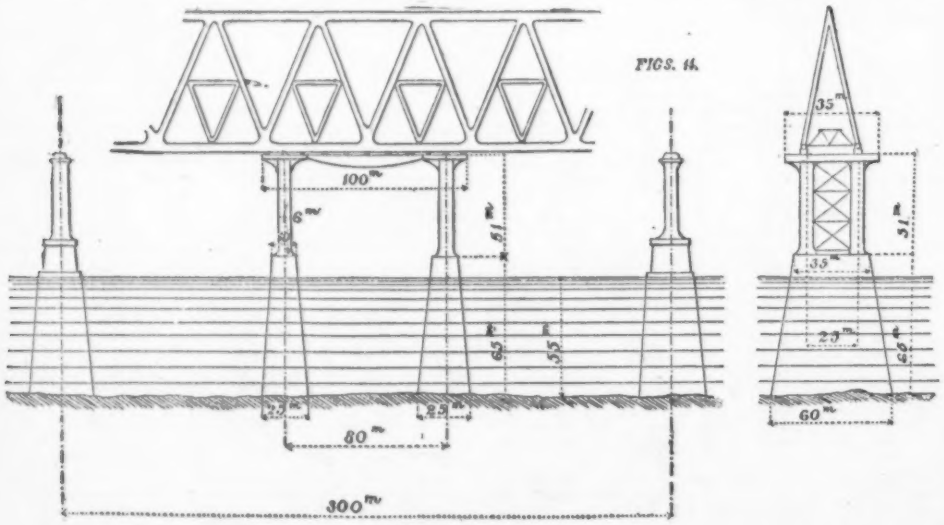


Fig. 17

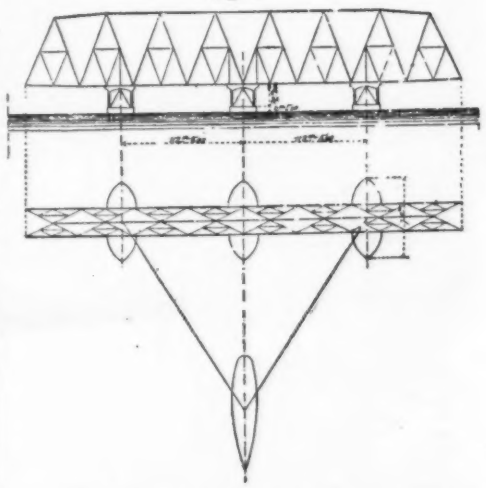
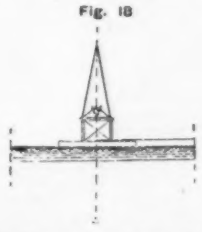
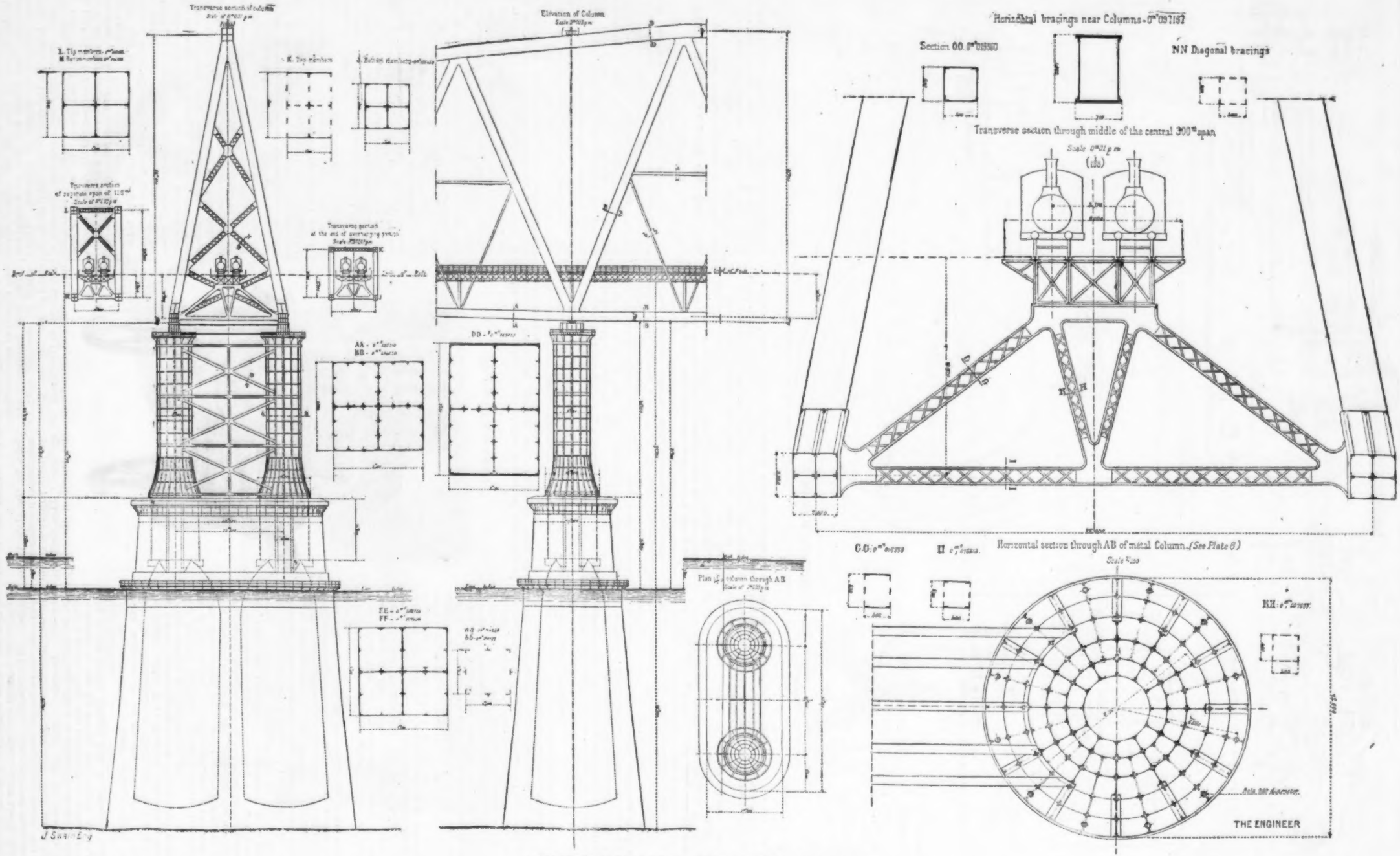


Fig. 18



* A paper read at the meeting of the Iron and Steel Institute, Paris, 1889.—*From the Engineer.*


Transverse section of column
Elevation of Column
Horizontal bracings near Columns - 0m097182
Section 00 0m019369
NN Diagonal bracings
Transverse section through middle of the central 300m span
Scale 0m01 p m
(1/10)
Transverse section at the end of overhanging girder
Scale 0m02 p m
AA - 0m52 sq m
BB - 0m44 sq m
DD - 0m52 sq m
EE - 0m44 sq m
FF - 0m36 sq m
Plan of column through AB
Scale 0m02 p m
CC 0m44 sq m
HH 0m36 sq m.
Horizontal section through AB of métal Column. (See Plate 6)
Scale 1/20
KK 0m36 sq m
THE ENGINEER

THE PROPOSED CHANNEL BRIDGE.

DESIGNED BY MESSRS. SCHNEIDER & CO. AND M. H. HERSENT; SIR JOHN FOWLER AND MR. BENJAMIN BAKER, MM. INST. C.E., CONSULTING ENGINEERS.

result in any given point, the consequence of which would be a crushing of the metal. The loading will be effected at high water. The barges will be brought under the bridge before the tide, and will raise it when the tide sets in. The whole will then be disengaged by transverse traction by means of winches. There may be three barges in the case of the heaviest span. The craft must therefore have a nominal capacity of about 3,200 tons, and a displacement of about 5,500 tons when fully loaded, including the weight of the scaffoldings provided for supporting the span. Barges 23 m. wide, 70 m. long, and drawing 6·50 m., will answer the purpose. They will also fully insure the stability of the whole.

The bridge may then sustain a considerable transverse pressure of wind without rendering the resulting inclination dangerous. The various barges will be connected between them by steel cables stretched crosswise, as is sometimes done in the case of bridges over rivers for the passage of artillery in times of war. The barges shall be provided with compartments that can be filled with water by means of sluice valves, so as to second the action of the tide during the discharging operations. It will thus become necessary to follow all the small movements of the sea, while nothing will prevent fair weather from being taken advantage of. The whole of the bridge and barges will be tugged by a larger steamer by means of crowfoot lashings, which is preferable to using several tugs, which might not act with the desirable uniformity. It will be understood that whenever the distance from fixed points either on the shore or at the piers makes it possible, it will be best to use direct traction and sufficiently powerful steam winches.

Upon the piers it will be necessary, at the point where the girders are to be laid down, to provide sufficiently powerful buffers to intercept the shocks due to the movement of the sea. When the bridge has reached the position it is to occupy, and is brought to rest in four points on the piers of masonry, the raising of it by means of hydraulic presses, arranged inside the rings which form the base of the metallic piers, shall be proceeded with. The bridge shall then be raised to the required height to enable the following four elements of the piers being placed in position. The presses will afterward be withdrawn, and the operation may continue in the same way until the span assumes its ultimate position. By adding to the weight to be thus raised the strain produced by the wind, it will be seen that each of the presses placed within the metal piers should be endowed with an effective power of 2,900 tons. It has been stated before that the large spans were not to be quite complete on the shore. As regards the two overhanging portions, they will be placed in position by a process of free erection similar to that used by the Creusot Company in 1865, for the bridge across the river El Cinco, Spain. As to the separate spans, they may be completed in the yard. They can then, by means of barges, be brought under the two overhanging portions which they are to connect, and there raised to their ultimate position by means of sufficiently powerful lifting apparatus.

(To be continued.)

ONE HUNDRED HORSE POWER GAS ENGINE.

THE pumps exhibited in the annex of class 52 of the Paris exposition were actuated by a one hundred h. p. gas engine, to which the gas was furnished by a small Dowson generator. This motor, which is the most powerful one with a single cylinder ever yet constructed, was built at the Powell works. It is of the "Simplex" type, devised by Messrs. Delamare-Debouteville & Malandin, and differs from the original only in certain details of construction.

The new features relate chiefly to the slide valve, which is provided with two admission apertures, instead of one (Fig. 3). These two ports supply a single one placed in the axis of the cylinder. This doubling has permitted of reducing the travel of the valve,

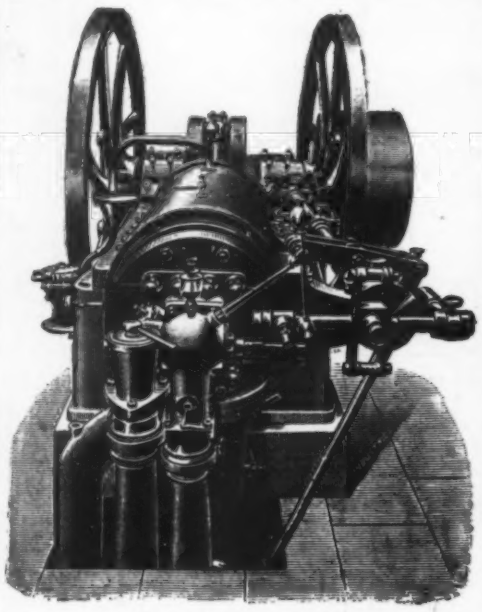


FIG. 10.—END VIEW.

while at the same time giving the gas a more direct passage. Belleville springs are employed with the screws that hold the valve box cover.

The mechanism that actuates the eduction valve has likewise been modified. It consists (Fig. 5) of a lever forming one of the parts of a jaw called "crocodile," and permitting of raising the valve with progressive velocities, in measure as the pressure decreases that tends to hold it upon its seat.

It will be seen, in fact, that the bearing point of this lever, which is at first very near the valve rod (in order to produce great force when the resistance is great), progressively moves away from it until the complete opening, which is effected with accelerated velocity.

In the third place must be mentioned the mechanism by means of which one man can start the engine, despite the strong initial compression used in this system. The arrangement that permits of obtaining this result, the practical value of which is beyond discussion, has already been described by us, and we shall simply recall the fact that the piston has to be arrested at about the middle of its stroke, and that, by means of a special cock, there is admitted into the cylinder a mixture of gas and air, the pressure of which, at its entrance, is sufficient to expel the inert products from the cylinder; after which, the lighting occurs, and the deflagration is great enough to start the motor.

After a little practice, the engineer becomes able to easily stop the motor at the proper point, but the case has been provided for in which that point might be exceeded. In order to pull back the lever to the position for starting, there is established at the side of the motor a cable that the engine man attaches to one of the spokes of the fly wheel, and which, through a motion of the latter, allows him to proceed unaided to adjust matters.

At the exposition, it took no longer than twenty or thirty minutes to set the gas generator in operation. Had the dimensions of the latter been a little larger, the engine might have been set running without waiting for the generator to reach the desired temperature for the normal production of gas.

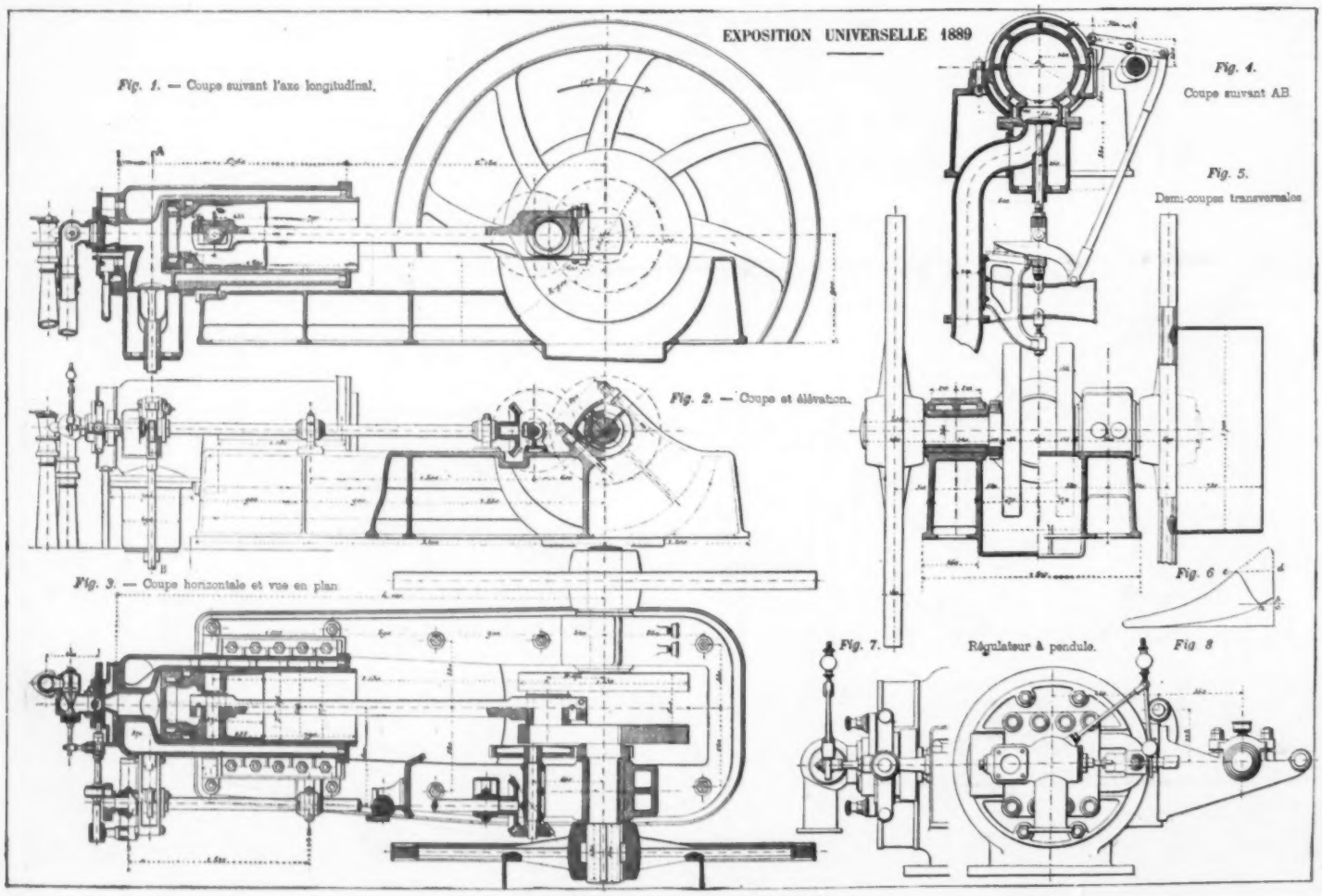
As regards ignition, which is one of the characteristics of this motor, it is effected with a chromic battery and a Ruhmkorff coil. For the electric spark produced by a contact at the proper moment, the inventors have judiciously substituted in the Simplex an uninterrupted succession of sparks between the platinum points that may be practically considered as a continuous spark. It is to the great efficacy of this mode of ignition that is due the possibility of giving the explosive mixture a strong compression beforehand, and of effecting a perceptible saving in the consumption. This certainty of ignition and its energy are of the most advantageous nature in the application under consideration, that is to say, in the running of an engine with poor gas.

The high compression given to the explosive mixture is not the only peculiarity worthy of remark in the phases of the cycle. It should likewise be remarked that the ignition, instead of being effected at the end of the stroke, is produced after the piston has effected its backward stroke, a length corresponding to an angle of about 15° of the crank. It results from this that the pressure upon the bearings of the driving shaft is reduced at the moment of the explosion, and that it is possible to attain a greater compression beforehand. This leads, besides, to a diminution in the volume of the inert gases remaining in the cylinder.

These various effects may be understood from an examination of the diagram in Fig. 6. From *a* to *b*, the mixture undergoes a sort of super-compression, which is so much the greater in proportion as the piston approaches the back of the cylinder. The dead space offered for the preservation of inert gases is thereby much reduced.

At first sight, the work necessitated by this super-compression might seem to be lost; but it should be remarked that it is recuperated in the return stroke. Moreover, if the explosion occurred at the beginning of the stroke, the inflammable mixture would not be so rich, and consequently the ordinate *c d* would be smaller, so that the line *d e* would be reduced in the same measure. The regulator has likewise been described. It is a double pendulum, having a constant tendency to place itself in the vertical, and provided with a tappet capable of bringing about the opening of the admission valve or leaving it closed. This effect depends upon the relation established between the possible velocity of the regulator's fall and the velocity of the engine.

In the cylinder, lubrication is effected by means of a drop lubricator, the oil from which falls into the interior of the mixture chamber and is carried along by



100 H. P. SIMPLEX GAS MOTOR.

the current of gas at the moment when the cylinder is relatively cold. All the other parts are lubricated by means of Stauffer compression lubricators.

This motor operates noiselessly. In order to deaden the shock at the escape, the inert gases are led into a box filled with stones. Its consumption seems to be very light, considering the small dimensions of the Dowson gas generator. Some accurate tests are soon to be made with the brake in order to establish the exact amount of the consumption in coal.—*Revue Industrielle.*

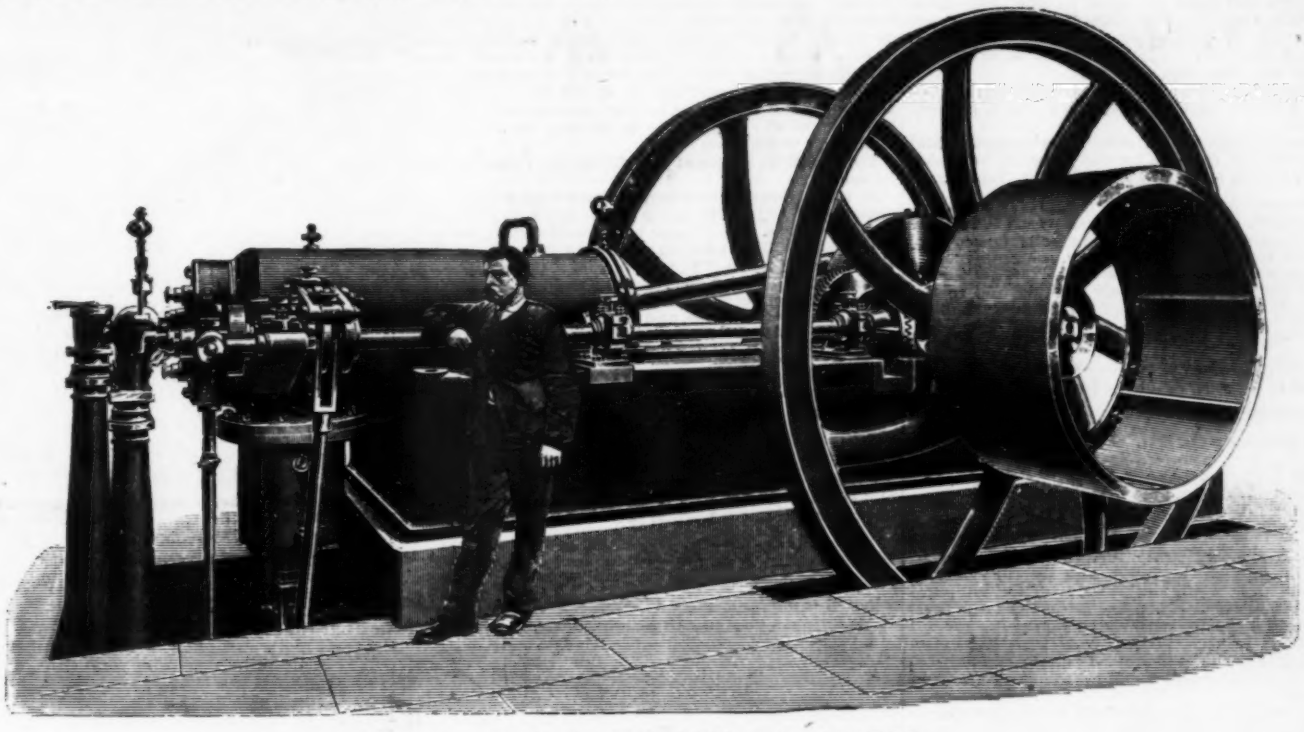


FIG. 9.—100 H. P. SIMPLEX GAS MOTOR.

THE VIAUR VIADUCT.

THE commission of inspectors general and government engineers appointed for the examination of the various designs for a viaduct over the valley of the Viaur selected the project of the Société de Construction des Batignolles. The minister of public works has ratified the selection and given the contract for constructing the work to the society just named.

Our plate represents the general arrangement of it. It consists of a large metallic framework composed of two symmetrical trusses connected by a central joint. Each of these trusses has the form of a triangle whose two sides are curvilinear and whose apex, opposite to the rectilinear side, is beneath, thus giving the structure in general the aspect of a metallic arch prolonged on each side of the springers by a cantilever. The sides of the triangle formed by the trusses constitute the bearers, which are connected by rigid tympanums composed of vertical or oblique bars. The springers rest upon masonry through the intermedium of junction axes. The extremities of the cantilevers support a span whose other extremity rests upon one of the masonry abutments that terminate the work. The object of these connecting-spans is to ward off the slight thrusts of the extremities of the cantilevers.

The two trusses are inclined upon the vertical in such a way as to present at the springs the wide spacing necessary for the stability of the whole. At their upper end they support the crosspieces upon which the trackway rests. Cross braces, vertical and oblique, complete the structure.

This arrangement has the following advantages:

(1.) The presence of three joints permits of an accurate determination of the thrusts, from which is at once deduced the stresses to which the various parts of the framework are submitted, for there are no superabundant pieces.

(2.) Neither during the mounting of the bridge nor while it is in service are there any stresses developed other than those that result from the weight proper, from the vertical loads, and from the wind.

(3.) The jointing of the key permits of keying the arch with simplicity, and without there being established, in any part, abnormal stresses difficult to determine, and such as may occur in continuous arches with a key.

(4.) The cantilever portion diminishes the thrusts, gives rise to a better distribution of the stresses, and facilitates the mounting. During this operation, the central part is held in partial equilibrium, in the first place, by the cantilever, and in the second by properly anchored tie bars whose action in nowise modifies the stresses when once the structure is completed.

(5.) The action of the variation of temperature is null upon the work of the metal of the trusses, on account of the joints.

The possible distortions of the structure or of the trackway have been studied with great care, under the action of vertical loads, of the wind, or of the variation of the temperature. They are very moderate, and less than those of the largest structures of the kind in existence. The proportions are such that the arch cannot open at the key under the action of the most violent wind, and, moreover, in order to dispel all fear on this subject, the key has been provided with rods that completely unite the trusses at this point without interfering in any way with the motion of the joint.

The following are the principal dimensions of the structure:

	Feet.
Total length	1,508
Length of metallic part	1,344
Opening of the central span	820
" " each shore span	262
Height of rail above the bottom of the valley	383
Pitch of the arch	149

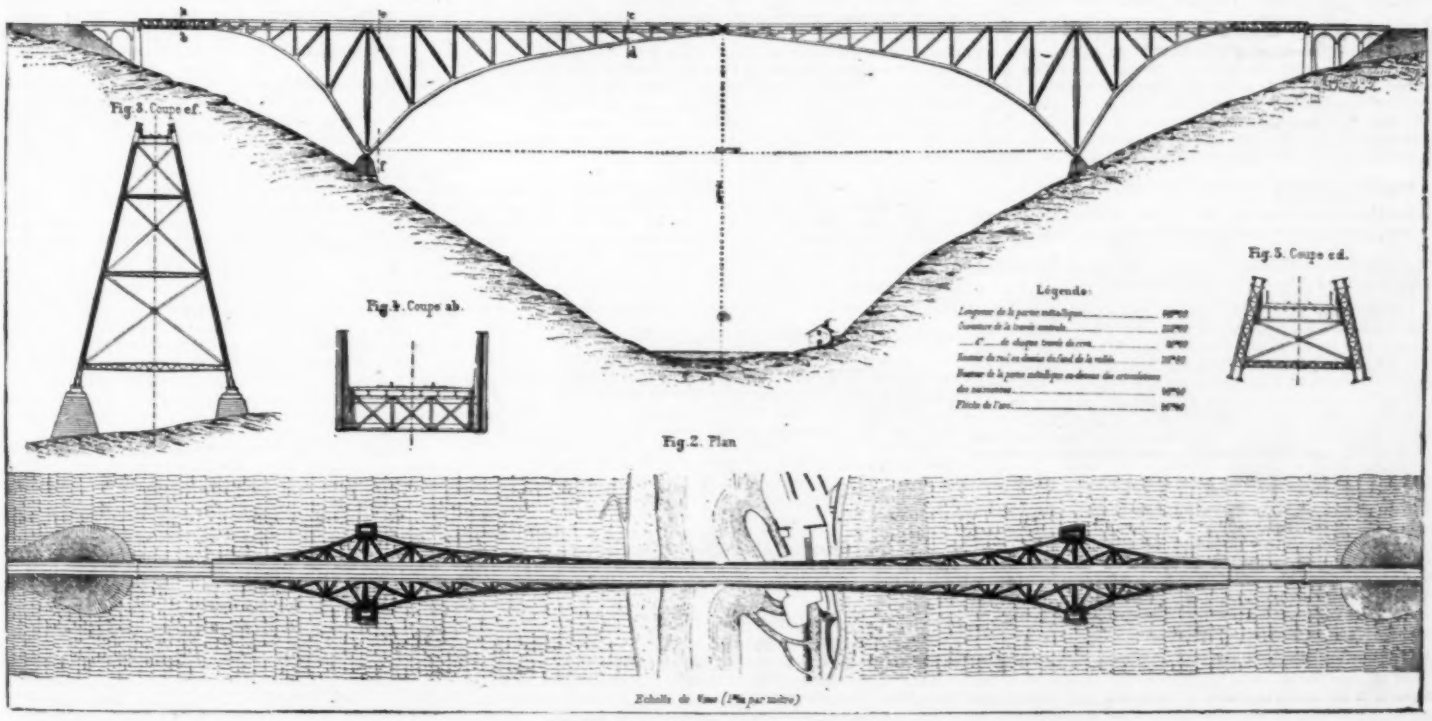
The 820 foot opening of the central span of this viaduct will be the widest of any of the bridges existing in France. The large arch of the Garabit viaduct, in fact, has an opening of but 540 feet, and the rail is about 400 feet above the bottom of the valley. In Scotland, the bridge constructing over the Forth will have two arches, each measuring 1,700 feet from axis to axis of the piers.—*Le Genie Civil.*

[ENGINEERING.]

ON THE ACTION OF SAILS.

By H. C. VOGT.

THERE is scarcely any part of technical science more neglected than that of aerodynamics, notwithstanding the fact that this science is of the greatest importance in correctly understanding the action of sails, which for



THE VIAUR VIADUCT.

thousands of years have been the principal means of propelling ships.

Even at the present time it is very doubtful if sailing ships (properly rigged, and especially of the fore-and-aft type) could not regain their supremacy for long voyages, for wind power cannot be neglected, as it is a power given gratuitously.

A fine sailing ship is able to perform about 50 per cent. of the work of a steamer on long voyages, and would perform still more if rigged in due accordance with scientific principles, and if furnished with proper auxiliary power for calm weather, in which latter case a sailing ship is utterly helpless, and can be driven by a current in any direction.

Having occupied myself for many years with aerodynamics, I desire to state some few rules respecting it:

For normal impact, general atmospheric pressure and temperature 0, the formula for the pressure or resistance, T_1, of the air striking with a certain velocity, v, on a plane area, A, is: $T_1 = q\,A\,v^{1{\cdot}11}$; 1·11 is an exponent denoting how the pressure varies with the size of the area, A, expressed in square feet—the larger area being similar to the unit area—q is a coefficient varying with the velocity, v. T_1 is also expressible as a function of the mass, M, of the air striking and of the rarefaction, a, on the rear side of the surface, that is: $T_1 = q\,A\,v^{1{\cdot}11} = M\,v + a$, where $M = \frac{\gamma\,A\,v}{g}$, γ is the weight of one cubic foot of air, or about $\frac{1}{13}$ lb., g is the acceleration of the gravity; the effect on the windward side of the surface would be consequently $M\,v = \frac{\gamma}{g}\,A\,v^2 = \frac{1}{13}\,A\,v^2$, if nothing were lost. For practical purposes the formula $T_1 = q\,A\,v^{1{\cdot}11}$ is the most convenient, and the values for q are:

When v is about 20 ft. per second, $q = \frac{1}{130}$; v about 60 ft. per second, $q = \frac{1}{115}$; v about 100 ft. per second, $q = \frac{1}{110}$.

At 400 ft. per second the resistance commences to vary with the cube of the speed, and by the velocity of the sound at still higher powers. This comparatively great increase in resistance arises from the rarefaction behind a surface with sharp edges.

When a body is interposed, such as with flat cylindrical projectiles, the resistance is much smaller, because the air is better able to fill up the rarefaction on the rear side.

The said formulæ apply especially to plane areas of canvas expanded tightly over a frame; curvature against the wind increases the resistance greatly.

The importance of the exponent 1·11 in the formula $T_1 = M\,v + a = q\,A\,v^{1{\cdot}11}$ can be best shown by an example: Suppose a big sailing ship had a sail area of 20,000 square feet, distributed on twenty sails of square shape of an average of 1,000 square feet each, then the total normal pressure, with a wind velocity of 20 ft. per second, would be $T_1 = \frac{1}{130} \cdot 20^{1{\cdot}11} \cdot 1{,}000 \cdot 400 = 34{,}400$ lb.; but if it was possible to comprise the whole sail area in one square sail, the same pressure would be obtained by 15,000 square feet.

When a surface turns round an axis there is one point of the greatest importance, namely, the point of effort, in which the whole resistance of the surface is supposed to be concentrated.

For a rectangular surface turning round one of its sides, the point of effort is at a distance of three-quarters of the length of the other side from the axis, and when now the circular speed of this point is compared with the rectilineal speed of the same surface, moving normally to its own extension with the same speed as the point of effort, then it is found that the resistance is about three times greater for the surface turning round its side.

When, therefore, v signifies the speed of the point of effort under the said circumstances, q in the formula $T_1 = q\,A\,v^{1{\cdot}11}$ has to be multiplied by nearly three. The increased resistance of a turning surface is due to the centrifugal force, which rarefies the air on its leeward side, whereas on the windward side the air has a tendency to move inward toward the axis, because the pressure decreases that way, and the centrifugal force cannot therefore remove the air from that windward side.

In connection with this it should be mentioned that when a tube is fixed perpendicularly to a hollow axle (the air in both communicating), then, when the axle revolves, the end of the tube will describe a circle; when one end of the hollow axle is shut, while the other communicates with a manometer, it will be found, as Captain Rung, of the Danish artillery, pointed out, that the rarefaction in the tube exactly follows the law of the centrifugal force, when in the formula $q_1 \frac{m\,v^2}{r}$, m signifies the mass of air in the tube, r the length of the tube, and v the velocity at its end, q_1 is a coefficient.

The rarefaction on the leeward side of a revolving surface was found in a similar manner.

In the formula $T_1 = q\,A\,v^{1{\cdot}11}$ just mentioned, q is about $\frac{1}{13}$ for speeds about 50 ft. per second, and comparing this with the formula for the resistance of a surface in water, which is 1·1 $A\,v^2$, it is seen that the resistance of the air is about twice as great as the relation between the specific gravities of air and water, which is $\frac{1}{13}$ (still it is not known if the formula 1·1 $A\,v^2$ holds for as great a speed as 50 ft. per second, and if nothing was lost by blows and vibrations the resistance of the water would be $\frac{\gamma}{g}\,A\,v^2 = 2\,A\,v^2$, where γ is the weight of a cubic foot of water = 64·8, and in addition to this comes the rarefaction on the rear side).

The air rebounds on account of its elasticity, and gives a high resistance in proportion to the mass moved, wherefore the efficiency of a centrifugal fan is very much inferior to that of a centrifugal pump, while for the same reasons revolving sails can obtain higher efficiency than any other propeller.

The formula $T_1 = q\,A\,v^{1{\cdot}11} = M\,v + a$ gave the resistance of the air for normal impact or for an angle of incidence $a = 90$, but this case is unusual for sails; the angle of incidence of the resultant wind upon a sail is generally small, and on a close-hauled sail often not more than 10 deg.

When now the air impinges upon the same surface as previously, but under an angle of incidence a smaller than 90—see Fig. 1—then the mass of air striking is reduced to M sin a, and the component of the wind velocity normally to the surface is $v \sin a$; the normal effect of the striking air is consequently only $M\,v \sin^2 a$, but the whole normal pressure is in reality $T = Mv \sin^2 a + a$ where the pressure resulting from a or the rarefaction exceeds the thrust resulting from $M\,v \sin^2 a$ many times, when the angle of incidence is small. The rarefaction on the leeward side of a close-hauled sail is produced similarly to the rarefaction in a closed funnel or pipe, namely, by the suction from the wind passing over its edge, the boltrope of the sail corresponding to the edge of the funnel; the air on the leeward side of the sail, therefore, moves in the opposite direction to that on the windward side, as shown by the arrow. (The eddy wind.)

For practical purposes the following formulæ may be used:

If, as previously, the normal pressure on a sail is denoted by T_1, when the angle of incidence, a, is 90 deg., then for angles of incidence between 90 and 20, the normal pressure, T (consisting of $M\,v \sin^2 a$ and a, see Fig. 1), is about $T = \sin a\ T_1$; for $a = 15$ it is $T = 1{\cdot}2 \sin a\ T_1$; and for a about 6 deg., $T = 1{\cdot}5 \sin a\ T_1$.

The relation between the resistance in the wind direction, r, see the figure, and the normal pressure, T_1, is very nearly $\frac{r}{T_1} = \sin a$, for a plane surface, while for a surface with about the same curvature as a sail or a bird's wing we have

$$\frac{r}{T_1} = \frac{2 - \sin a}{\sqrt{\sin^3 a}}$$

for values of a greater than 20 deg., while for values of a smaller than 20 deg. the friction becomes greater in proportion to the normal pressure, so we must put

$$\frac{r}{T_1} = k\,\frac{2 - \sin a}{\sqrt{\sin^3 a}}$$

where $k = 0{\cdot}8$ for a about 12 deg. The application of these formulæ on a practical case can easily be given:

A yacht of 150 tons displacement makes in a fresh

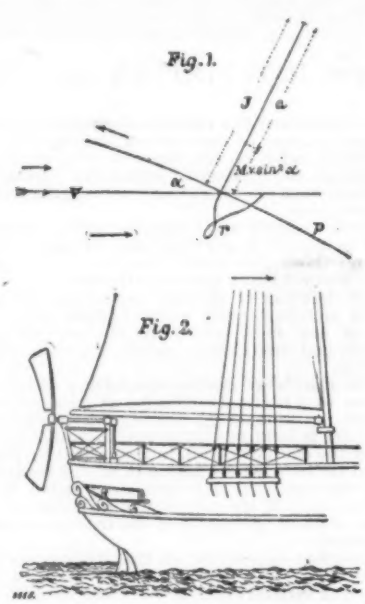


Fig. 1.

Fig. 2.

breeze of 22 ft. per second a speed of 7·5 knots, or 12 ft. per second, by sailing four points from the wind; by which the resultant wind becomes 31·5 ft. per second, making an angle of 30 deg. with the keel. The foot of the mainsail makes an angle of 10·5 deg. with the keel, but the average angle of the sails with the keel is 14 deg., at which the angle of incidence of the resultant wind on the sails becomes 16 deg., the sail area is 4,500 square feet, and let us, for the sake of simplicity, consider this concentrated in one square sail at which the pressure for $a = 90$ deg. would be:

$T_1 = \frac{1}{130} \cdot 4500 \cdot (31{\cdot}5)^{1{\cdot}11} = 25{,}000$ lb. for normal impact, but the angle of incidence a is 16 deg., at which the normal pressure becomes: $T = 1{\cdot}1 \sin 16$ deg. $T_1 = 7{,}700$ lb.; as the sail makes an average angle of 14 deg. with the keel, the forward component to surmount the resistances will be about 7,700 cos 76 deg. = 1.850 lb., of this the water resistance is somewhat over 1,000 lb. The resistance, r, in the direction of the resultant wind, can be found by the formula $\frac{r}{T} = 0{\cdot}9\,\frac{2 - \sin 16\text{ deg.}}{\sqrt{(\sin 16)^3}}$ or r about $\frac{1}{11}$ T, but on account of the great friction on canvas it may be more accurate to put $r = \frac{1}{10}$ T = 770 lb., but the resultant wind makes an angle of 30 deg. with the keel, wherefore the resistance in the direction of the keel will be: 770 cos 30 deg., or about 670 lb.; the resistance of the air against hull and rigging may be about 180 lb., whereat 1,000 + 670 + 180 makes 1 850 lb. = the forward component of the normal pressure on the sails.

The normal pressure on the sails was 7,700 lb., and the greatest part of this pressure results from the rarefaction on the rear side of the sails, that part, namely, which is derived from the windward side is only $M\,v \sin^2 a = \frac{\gamma}{g}\,A\,v^2 \sin^2 16 = \frac{1}{13}\,4{,}500\,(31{\cdot}5)^2 \times 0{\cdot}075 = 880$ lb., and the rest 7,700 — 880 = 6,820 lb., results from the rarefaction on the rear side of the sails.

The importance of having sails impermeable will be seen from the following:

Fifty years ago, when the canvas was more open than now, people were glad when they could advance one knot an hour straight against the wind by beating; nowadays a good pleasure yacht advances five knots an hour straight against the wind, under the same circumstances, and much finer results would, of course, be obtained if sails were perfectly impermeable and had a perfectly smooth surface to avoid the enormous loss by friction.

Covering both sides of the sails with oilskin would be one method, if no better proposals are made. Sails thus made impermeable would be more expensive, but, on the other hand, a much smaller area would answer the same purposes, and the sails would be protected against moisture.

In addition to what is now said concerning stationary sails, a few remarks on revolving sails may, perhaps, also be made.

In the first place it should be recalled to mind that among the different illustrations given to "the principle of the conservation of energy" is the following, namely, that a propeller working in the elastic air yields a greater thrust than in inelastic water, because the losses in energy are greater in water than in air, when equal power is employed in both cases. In addition to this, revolving sails utilize the natural wind power, or 75 per cent. of the winds, the whole compass round, augment their thrust; revolving sails are, in fact, benefited by the same winds as well-trimmed stationary sails.

Going straight against the wind with revolving sails is just as if sailing close-hauled with stationary sails. Supposing, for example, that a hurricane straight against the course of the vessel has a velocity of 100 ft. per second, and the proper speed of the points of effort of the revolving sails is also 100 ft. per second, then the result is as if sailing four points from the wind. We shall not enter upon the experimental results here, as they were all brought before the British Association last year, and published in *Industries* and in the *Engineer*.

In accounting for the losses of a propeller in air and water, it will easily be understood why the thrust is a trifle inferior in water, where the losses are: (1) Loss by friction; (2) loss by throwing out water in wrong directions and imparting energy to the same; (3) loss by blows and vibrations.

The losses corresponding to (3) do not occur in the air; but the other losses are supposed to be very nearly the same in air and water, because the thrusts of propellers in air and water differ very little. As the object of an air propeller is that of making a rarefaction in front of itself, it can easily be understood that its size has nothing to do with the relation between the specific gravities of air and water.

The sucking action of the wind, passing the front edges of revolving sails, upon the air on the leeward side of the sails, is one of the agents in producing a rarefaction, as already mentioned, but the centrifugal force is the other and more important agent.

Experiments made last winter in Copenhagen prove that the rarefaction on the leeward side of revolving sails can be expressed as a function of the centrifugal force

$$f\,\frac{m\,v^2}{v} = f\,\frac{A\,r.\,v^2}{g\,r} = f\,\frac{A}{g\,r}\,v^2$$

where g is the acceleration of the gravity, A the area of the wings, and v the velocity at the circumference; from this it is understood that, as also proved by experiments, the thrust of a propeller, just the same whether in air or water, varies very nearly with the third power of the number of its revolutions, f differs considerably in accordance with the shape of the propeller used, and it requires still more experiments to determine the law for its variation. As the pressure of the air on the windward side of revolving sails decreases toward the axis, because the proper velocity of the sails decreases that way, then there will be a tendency of the air to move toward the axis on the windward side, thus counteracting the centrifugal force, which therefore only is able to remove the air from the lee side; the air thus removed is sent behind the propeller without deviating much to the sides, because the air is also drawn in from the sides toward the rarefaction, the two tendencies thus counteracting each other.

The quantity of fluid thrown behind a propeller is necessarily less than the quantity drawn toward it by means of the rarefaction in front of it; it is therefore by means of the rarefaction in front of a propeller that the momentum, and consequently the thrust, is created.

Sometimes investigators when calculating the friction of a water propeller take both sides into consideration, quite forgetting that on the leeward side there is a partial rarefaction, and the fluid on the leeward side has an eddy motion contrary to the main current.

The formula for calculating area and speed of revolution of an air propeller has been given previously and published in *Industries* and the *Engineer*. It may, however, now be mentioned that a two-bladed auxiliary propeller for a ship of 1,000 tons displacement supposed to have a resistance of 1,000 lb. at about four knots would have a diameter of about 17 ft., with 55 square feet area, and make 2·6 revolutions per second, exerting the said thrust of 1,000 lb., and require 30 horse power to drive it. The two sails could be made of canvas covered with oilskin, and they should be made like ordinary sails to fold and unfold, and the little vertical engine to drive the sails, as shown on the sketch, could be furnished with steam from the boiler which generally is kept on board large sailing ships to drive steam winches, etc.

Numerous attempts have been made to furnish large sailing ships with auxiliary water propellers, but water propellers, as is well known, occasion a considerable augmentation in the resistance of a ship, 20 to 40 per cent., by creating a negative pressure round the stern, especially when the propeller is very small in comparison with the hull.

A water propeller detracts also from the sailing qualities of a ship, and it spoils the cargo space to have an engine and boiler under the deck.

Sails in the air and propeller in the water do not work well together, wherefore a ship must be driven either by reacting entirely upon the water or upon the air by means of stationary and, in calm weather, by means of revolving sails.

The sketch shows the stern of a ship fitted with revolving sails as auxiliary power.

Aagade No. 4, Copenhagen, Denmark.

THE ANCHORING OF BUILDINGS—PRESENT DEFECTS AND HOW IMPROVED.*

By HENRY A. GOETZ, New Albany, Ind.

IT is a hackneyed phrase that property destroyed by fire is so much available capital utterly "wiped out." This national waste now amounts to $115,000,000 yearly. It may be that the owner has insurance to cover the loss, but he is none the richer and the public or the state is the poorer, for an insurance company collects merely a number of dollars from the public and pays out to the individual but 60 or 65 cents as indemnity.

The insurance press is correct in saying that the fire appliances are being improved every day, that the firemen are doing their work as well as it can be done, but notwithstanding this, the fires cannot be confined to the point of ignition, thereby showing that we must look for the cause in our existing methods of construction, and that any improvement in the fire situation of the future must be looked for in improved architectural methods.

The *Chronicle*, an insurance journal that makes a specialty of gathering fire statistics, says editorially that the probability of a risk taking fire from the outside (that is, from exposure) is almost as great as all interior causes combined.

Mr. D. A. Heald, president of the National Board of Underwriters, in his address at the annual meeting in May, after giving statistics to support his assertion, said: "This exhibit is an evidence that too little attention is paid to exposures as an important factor in rating, and should need no further argument to enforce the lesson it inculcates."

The *American Exchange and Review*, edited by J. H. Fowler, the insurance historian, has a thoughtful article on the "exposure hazard;" it says the exposure hazard is the proper object to aim at. Fire proofing and fire prevention as absolute conditions are fallacies, but the reduction of the exposure hazard is a practicable reduction of the fire hazard. The problem to be worked out is, By how many degrees can the mean circle of combustion be narrowed toward the point of ignition?

According to the *Chronicle* fire tables, the loss in 1888 on property where the fire originated was $79,000,000. The remainder of the loss, or $32,000,000, was caused by the spreading of the flames to adjoining property; that is, by exposure. In its review on the fire situation it says that the rate of exposure seems to be slowly increasing; and judging by preceding years, for every risk burned by a fire originating on the premises, seven-tenths of the adjoining risk was burned by the spreading of the flames.

It therefore seems to be a well settled fact, and may be accepted as one of the laws that mark the fire waste of this country, that the average fire will damage or destroy not only the property in which it originates but seven-tenths of an adjacent risk.

During 1888 there occurred twenty-six large fires, at which there was an average loss of $423,000. These fires occurred mostly in the business part of town, and show conclusively that our methods of construction are faulty. Many such business blocks are to be found in your city, and while they may stand for years, propped up as they are by supporting each other, the danger is continually there, that they may be death traps to many, ever ready to fall at the slightest provocation.

The *Firemen's Herald* says, in an editorial, that of the great number killed each year by falling walls, not a few were firemen. This calls to mind the faulty anchorage employed by our modern architects. The fire walls are rarely of proper thickness, while the joists are usually fixed solidly, so that in falling they force the wall to buckle, causing it to fall out or in.

You have heard it said that unsafe buildings are the cause of these extraordinary losses, but you cannot find the man that ever put up a dangerous building. You cannot find the man that admits his job to be unsafe or faulty. Why, if the building should fall during its construction, you will not be able to blame the architect, because the builder did not use good material, mortar, etc.; and if you attempt to blame the builder, he will prove to your entire satisfaction that he followed the plans and specification.

Not a few architects ever give the methods of anchoring any study whatever. One I met openly told me that he never bothered about the anchors, and left it entirely with the builder to use what he liked. I found building inspectors who had not noticed what their own law said on the subject. I find many laws to be very obscure as to what was wanted for anchorage, and in others, where the law was more explicit, it was not noticed or complied with. I therefore assert that the most important subject connected with building, namely, the method by which the structure is held together, is being overlooked and neglected by architect, builder, and inspector alike. General usage and common sense require the joists to be cut on a splay of about three inches to the foot, it being well known that this cutting at an angle is done to permit the joists to fall out, without damage to the wall, but this advantage is undone by fastening the tie to joist and wall so that they cannot part.

All methods of anchoring in use at present have a tendency to pull the walls down in case of fire.

Chief Dougherty, of Indianapolis, reports that last January, at the $700,000 fire in his city, the Stotchons lounge factory plainly illustrated the faulty anchorage, for both side walls fell early in the fight, exposing much property to destruction, while the front and rear walls stood (these are usually not anchored so securely as the side walls). The rear wall that remained standing protected from damage a building larger than any of those burned.

Chief Steers, of Providence, reports that, had the walls of the Chase and Arnold block (the building in which the fire originated) remained standing, the fire would have been checked much sooner, and the consequent damage, $455,000, greatly lessened.

Chief Foley, of Milwaukee, reports that, within a very short time after the arrival of the first engine, the north side wall fell, carrying with it the dividing wall. This of course was the destruction of the whole building, involving several parties, and causing a loss of $192,000. It was at this fire that two men were killed by the falling walls and seven others more or less seriously injured.

In the report of the fire at Baltimore in September, loss $894,000, the men were hastening out of the adjoining building when the treacherous side wall fell over, burying under its great weight nine unfortunate firemen, seven being killed outright.

These cases could be multiplied indefinitely, and every fireman here can call to mind narrow escapes and accidents of this kind. Is it right, then, to permit the economical citizen to put up such death traps and jeopardize the lives of you and me?

It is self-evident and well known that a vertical standing wall of brick presents the most formidable barrier to the spread of flames. No known material

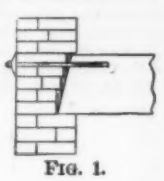


FIG. 1.

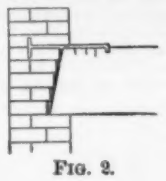


FIG. 2.

FIG. 3.

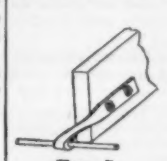
FIG. 4.

can resist fire as well or so long as brick. Therefore, all methods that have any tendency whatever to pull those walls of brick down should be condemned.

I will proceed now to show the many styles of anchors in use. I must say that I find no standard method in use anywhere, each builder having his own ideas on the subject; therefore, in some cities you will see every variety in use.

Anchors can be divided into two classes, namely, the one that is fastened to beam and reaches through the wall, shown in Fig. 1, and the tie that is fastened to beam and reaches only to the face brick, as in Fig. 2. You will notice that the joists are cut on an angle, so they can fall out, and are then fastened to the wall so they cannot fall out. Fig. 3 shows result in case the joists burn through at a fire, the anchor reaching through the wall having a tendency to throw the wall out, while Fig. 4 illustrates how the anchor that reaches to face brick will throw the wall inward. Fig. 5 is sometimes specified by our government. Fig. 6 is used a great deal in Boston. Fig. 7 belongs to Cincinnati, while Fig. 8 comes nearest to what New York wants. Fig. 9 fills the requirements of the law at Washington. Fig. 10 is not used very often. Figs. 11 and 12 are favorites with the supervising architect and many others, and plainly show how impossible it is for any joist to leave the wall without pulling it down. Fig. 14 is a wooden affair, and shows to what an extreme some builders will go without any regard for safety.

Figs. 15 to 21 illustrate the Goetz-Mitchell method of anchoring. It consists of a cast iron box of dovetail shape (whereby it is locked into the wall into which it is built) and an upwardly projecting lug at the bottom over which the joist is notched. In Fig. 16 interior side guides are provided which permit a circulation of air and prevent dry rot.



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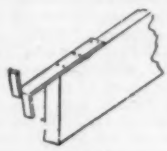

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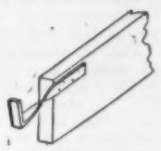


FIG. 7.

FIG. 8.

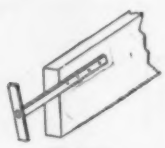


FIG. 9.

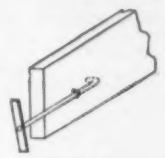


FIG. 10.

FIG. 11.

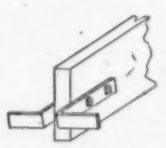


FIG. 12.

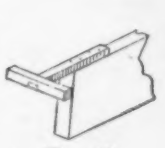


FIG. 14.

With this method an additional weight on joists increases the bondage. The falling joist frees its own anchorage, with no tendency to pull the wall along. No fire or smoke can pass through the box that remains in the wall. No liability of joists taking fire in being built in close proximity to smoke or heat flues. It is impossible for a defective flue to ignite the joist ends. There is not another method in use that can claim one single advantage mentioned. For heavy timbers the bottom is extended outwardly as in Fig. 17, thereby forming a secure bed plate. Figs. 18 and 19 show how box is bonded to wall, forming a part of the same, and Figs. 20 and 21 show the Goetz-Mitchell method applied to a party or partition wall. Here is where the great danger is during the great fires. You will see that with this method the joist upon one side can burn out while every joist upon the other side is holding the wall in position. No fire can pass through the wall to ignite the joist resting upon the same wall. No joist can ever meet in the wall or overlap. With this method of anchoring a party wall is a practical fire wall.

The heaviest losses occur in our warehouse and business blocks. A fire usually burns out a post or a beam

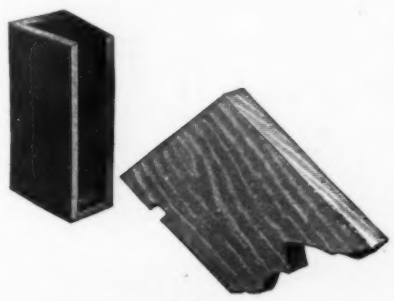


FIG. 15.

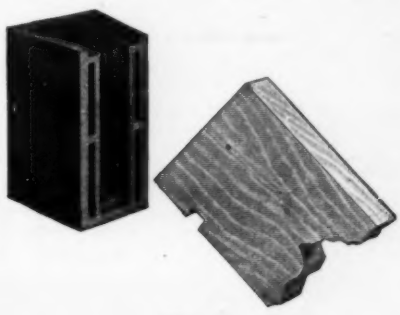


FIG. 16.

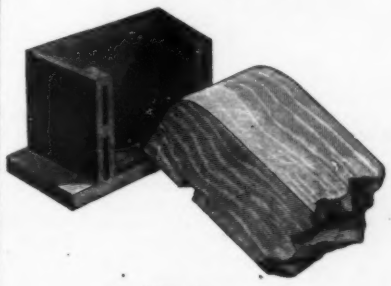


FIG. 17.

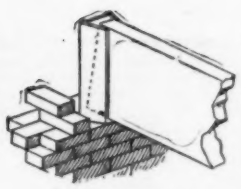


FIG. 18.

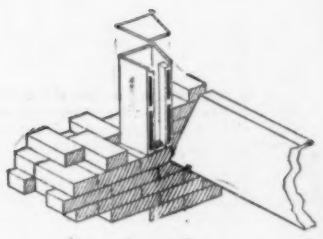


FIG. 19.

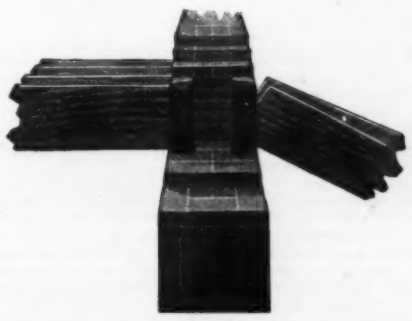


FIG. 20.

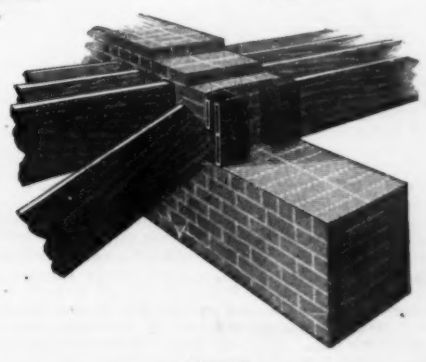


FIG. 21.

* A paper read before the National Association of Fire Engineers, September 11, 1889, at Kansas City.

in a vital section, thereby causing the whole structure to fall before it is burned, often injuring many persons. I therefore insist that methods of construction be adopted so that only such parts will fall as are burned through, and these falling parts shall have no tendency to pull the balance of the structure along.

In the following illustrations you will see how universally this idea is neglected, and that nearly all the present methods of construction have one very serious fault, namely, if one part burns through and falls, it will pull down the remaining parts.

Fig. 22, although the poorest and crudest adjustment of material, is used oftenest, especially where the builder fills also the place of architect and contractor. Fig. 23 shows the result, and illustrates why many buildings fall so suddenly. Fig. 24 uses an iron cap, evidently put there as an improvement, but no part can fall without destruction to the balance. Fig. 25 has the same serious objection. An improvement over the foregoing are the side plates, which prevent the beam from warping out of position. Fig. 26 is used very seldom. It has no merit and is difficult to place in position. Fig. 27 was the method used in the large tannery of Chicago that burned out and resulted in a complete destruction. Fig. 28 is now being used in an eight story building nearly finished. This architect made the plans with an idea that it would never need to come apart. Fig. 29 is a step forward. Fig. 30 is an improvement, in that it prevents the crushing of material, and consequent settling of the structure. Fig. 31 is employed a great deal in the Louisville tobacco warehouses; the four inch base for such heavy timbers is not enough, and if the tie is strong enough to hold the parts together, it is also strong enough to pull the remaining parts down, should one of the members be compelled to fail. Fig. 32 is the method formerly specified by the factory mutuals. The objections are the ties are fastened on top and the iron pintle is a source of great weakness.

Fig. 33 is a modification of the same plan. This has a straight pintle, while the foregoing has a round one. Fig. 34 is another change that provides a better seat for the heavy timbers. Fig. 35 is the first real improvement in construction. In this method any horizontal beam can fall away without damage to the post, but the fault lies in the danger of overthrowing the cap should too much weight be brought to bear upon the remaining beam. Fig. 36 is nearly the same thing, only it is easier to put up on account of the sockets in which the posts are fitted. In Fig. 37 the horizontal timbers are held in position by the upper post, this forming a key. It permits the falling of beams, but the plan is insecure from the fact that no bolts or side plates are used to hold such heavy timbers in position.

Fig. 38 is the method invented by Henry A. Goetz, of New Albany, Ind. No crushing of material. The posts rest end to end, with no timber intervening. The cap and posts are securely bolted together, with no possible chance of being displaced by any accident. The horizontal timbers can fall away without any tendency whatever to pull or injure the remaining parts. The upwardly extending sides prevent the timbers from warping out of their position, and finally the sustaining column can burn away and still the structure will not fall, because the horizontal beams rest upon the casting. The casting is bolted to upper column, and this column forms the key that holds the parts together. Two holes in casting provide air to prevent dry rotting. These methods are indorsed and recommended by the following architects of national fame: Burnham & Root, N. S. Patton, Pond & Pond, Edbrooke & Burnham, of Chicago; R. S. Buffington, Minneapolis; A. B. Mullet, J. G. Hill, of Washington; N. B. Bacon, Toledo; S. J. F. Thayer, Boston; Mason Maury, Louisville, and many others.

You may ask, What has a fire chief to do with methods of construction? I am certain it would add considerably to a chief's executive ability for him to be intimately acquainted with existing methods of construction. He should notice how a building is put up. His eye should see any fault in a structure, and he should be familiar with the interior arrangement, of course mainly from a "fire loss" point of view. Such knowledge will often save life. His judgment as to the length of time a burning structure will stand will be almost perfect; he will not be liable to make serious mistakes through ignorance, and, best of all, he will get better service out of his men on account of the confidence they will have in his orders.

Who, then, has a greater interest or a superior right to advise proper methods of construction than the fireman? It is he who risks his life to save the property of others and goes into a building when everybody else leaves it. I hope, therefore, that the day may not be far distant when every fire chief shall have the power to say as to how a building shall be put up. It gives me much pleasure to have permission to refer to many chiefs now present at this convention, among them being the honored name of Ex-Chief John S. Damrell, of Boston.

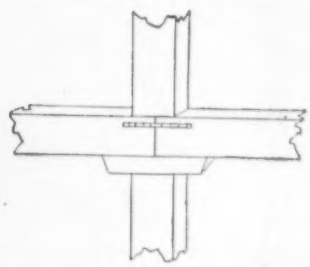


FIG. 22.

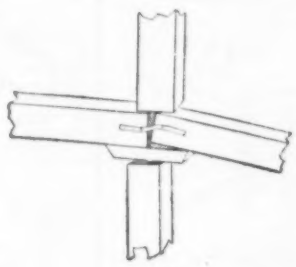


FIG. 23.

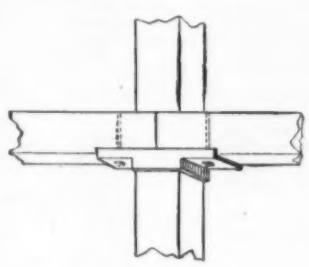


FIG. 24.

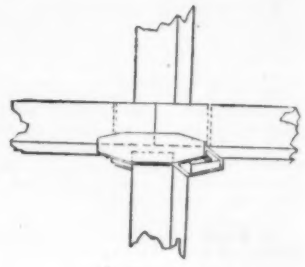


FIG. 25.

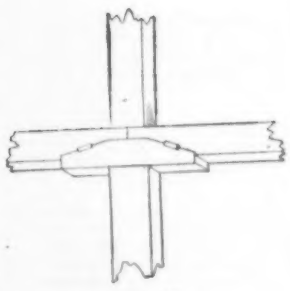


FIG. 26.

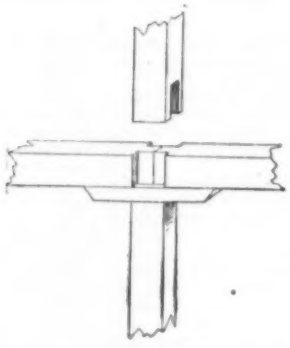


FIG. 27.

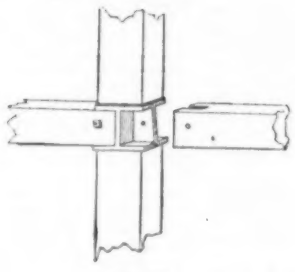


FIG. 28.

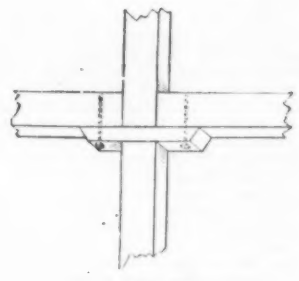


FIG. 29.

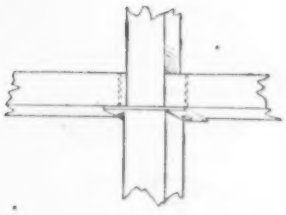


FIG. 30.

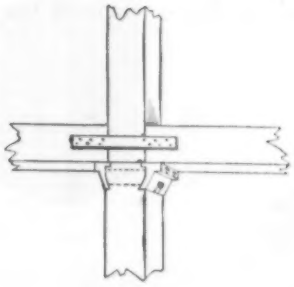


FIG. 31.

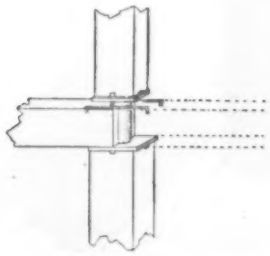


FIG. 32.

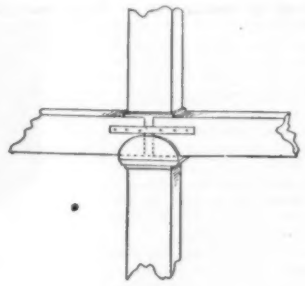


FIG. 33.

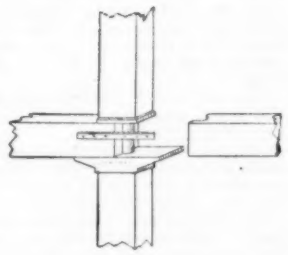


FIG. 34.

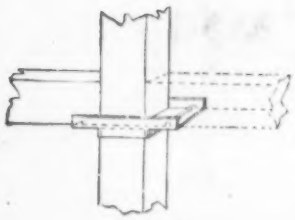


FIG. 35.

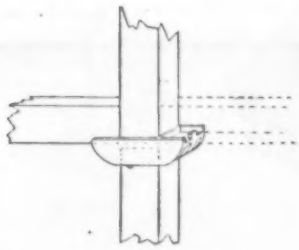


FIG. 36.

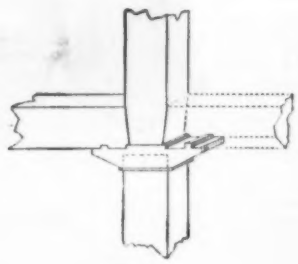


FIG. 37.

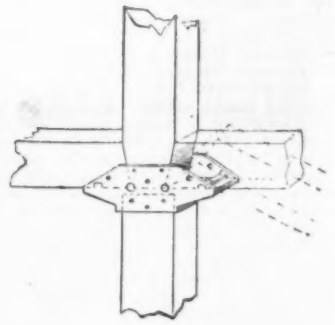


FIG. 38.

URANIUM-GOLD PRINTING.

THE following is a description of an original method of printing from the negative that is at once simple, pleasing, and inexpensive. As it is by ferric agency that the "plate is prepared" for the reception of the compound that forms the ultimate image, the process may reasonably be termed an "iron" one. The few details here presented take no claim to be considered exhaustive, and should rather be regarded as designed to elicit the ideas and attract the experiments of others.

The *rationale* of the process may be thus stated:

Suppose paper coated with ferric oxalate to be exposed to light behind a negative, there is formed a positive impression, chiefly in ferrous oxalate, which will easily reduce and be replaced by certain metallic compounds, as, for instance, gold and silver, and probably others.

Thus we can obtain silver pictures by direct chemical substitution, as well as by printing out in the chloride or development.

Among the important compounds that ferrous oxalate is powerless to reduce may be classed those of uranium. But if to a per-salt of this metal in solution there is added a small quantity of gold chloride, and the combined solution is washed over the ferrous picture, a ready deposition takes place.

The gold while being itself thrown down carries the uranium with it, and becomes intimately united therewith to form the final positive image. The portions of the picture that were not affected by light have no reaction with the "developing" solution, and are thereby dissolved away, leaving only a surface of plain paper.

In the practical working of this method of printing the following are to be provided:

Paper coated with ferric oxalate, nitrate of uranium, chloride of gold, hydrochloric acid.

Iron per-oxalate is employed in several processes, but as the greater number of persons who handle it are ignorant of the facility with which it may be prepared,

a convenient method of making a small quantity due to Pizzighelli and Hubl is subjoined.

Dissolve two hundred grains of perchloride of iron in four ounces of water, heat to boiling point, and add hydrate of sodium—about 100 grains will be required—until an alkaline reaction is indicated. Wash the precipitate with warm water, and when it is neutral to test paper, free it from nearly all the water by squeezing it in a clean piece of linen. The reddish-brown mass of ferric hydrate should now be placed in a flask, or other suitable vessel, about a hundred grains of oxalic acid added to it, and the vessel set aside in the dark for two or three days.

The greenish-brown solution of ferric oxalate obtained at the end of that time should be filtered, and the amount of acid and iron therein contained determined by analysis. The solution should exhibit a decided acid reaction; if such is not the case, a few crystals of oxalic acid are to be added. The solution is unstable, hence it is inadvisable to prepare more than sufficient for immediate needs.

The quantity of sensitive solution to be taken for coating the paper should be in the proportion of one grain of ferric oxalate to each square inch of surface. The sensitized paper will not deteriorate for several weeks if shielded from damp and light; if it is desired to preserve it for longer periods, the addition of a grain of mercuric chloride to each ounce of ferric solution before coating the paper is said to exercise a preservative effect.

When the dried iron paper has been exposed in contact with the negative and the characteristic ferrous image obtained, it should be floated upon a solution compounded in the following proportions:

Nitrate of uranium	15 grains.
Chloride of gold	1 grain.
Water	1 ounce.

After the desired depth of deposition has been obtained, the picture should be passed through plain water followed by immersion in dilute hydrochloric acid, 1: 100, again treated with water, and finally allowed to dry.

The tone of the picture should be deep blue-black, and the image should not be deficient in vigor and balance. The proportions of the salts given above may be varied largely; the addition of more gold insures a corresponding increase of the purplish element in the color of the print; its diminution tends to the predominance of the cold black of deposited uranium. The greater the quantity of gold taken, the more rapid will the reduction proceed. The appreciation of the points immediately enumerated will place in the hands of the experimentalist every power to modify the color of the picture and to restrain or accelerate development.

As nitrate of uranium may be purchased at a lower rate than the silver salt, and the quantity of gold employed need not, on the whole, exceed the average taken for toning albumenate of silver prints, the comparative cost of the little process I have sketched could be ascertained without difficulty; I do not think it would exceed that of any silver process at present in favor.—*Thomas Bedding, in Br. Jour. of Photo.*

AUTOMATIC PHOTOGRAPHY.

THE apparatus herewith represented is designed to perform all the photographic operations necessary for obtaining the portrait of an individual who sits in front of it, and who has previously dropped a coin into the cash box.

The details of the external part of the apparatus are shown in Fig. 2. At the right is the slot into which the money is dropped that sets the apparatus in operation, and at the left directions are given as to the point upon which the eyes must be fixed during the exposure. Above, there is a series of dials divided into

FIG. 1.—AUTOMATIC PHOTOGRAPHIC APPARATUS.

sectors, and the hands of which indicate at every instant the operation that is taking place inside of the apparatus.

A few instants before the exposure, the head of the second dial passes over the words "Prepare yourself," and then "Attention," and as soon as it reaches the black sector bearing the word "Pose," the exposure begins and the bell that is observed above the dials rings as long as the exposure lasts, which is usually from three to six seconds. In a few instants (the total operation lasting but five minutes) the finished portrait makes its exit from the side.

Upon the whole, the apparatus prepares the sensitized film, develops the image, and finishes by drying and varnishing—the whole without an operator.

Many of our readers who are interested in photography, and who use plates all prepared, know that with these preparations the time of development, fixing, washing, and drying far exceeds the five minutes necessary for this automatic apparatus to give its result.

In order to avoid such lengths, the inventor, Mr. Enjalbert, has adopted a process which is scarcely ever employed except by itinerant photographers, but which has the advantage of giving a result in a few

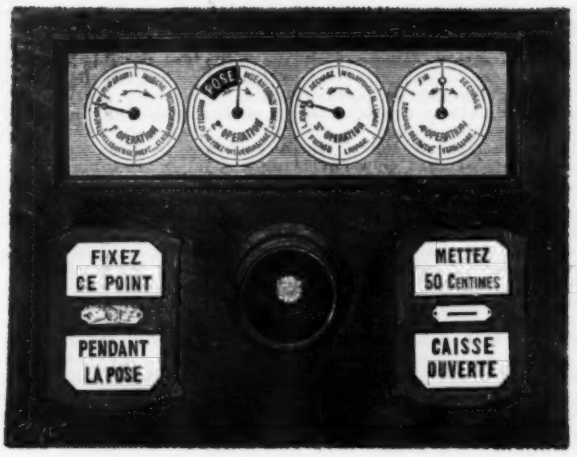


FIG. 2.—FRONT OF THE APPARATUS.

instants. This process, known under the name of ferrotype, consists in taking a picture with wet collodion upon a thin metal plate covered with perfectly black or glossy japan varnish. This picture, though negative, appears as positive by reflection, and, owing to the black background, appears sufficiently sharp. The same results may be observed with ordinary negatives, and many operators have the habit of putting the plate on their sleeve or before a dark cloth in order to see the image as a positive.

Although the advantages of ferrotypy are numerous, it offers the inconvenience of necessitating many operations, for it is necessary to prepare the plate with collodion, to sensitize it, and then, after exposure, to develop it, to fix the image, and to wash, dry, and varnish the plate. All that is done mechanically in the automatic apparatus.

In order to satisfy our curiosity, let us remove the front of the apparatus and examine its interior.

The lower part contains electric accumulators that actuate an electric motor. The upper part contains the various receptacles with the various products necessary, and the central part contains all the mechanism that permits of performing the various photographic operations (Fig. 3).

We shall not attempt to describe with accuracy this admirably conceived mechanism, but shall simply say that if the apparatus be opened and its operation be watched, we shall first see the column that contains the superposed plates that are separated by frames that are to inclose the pictures when finished. These

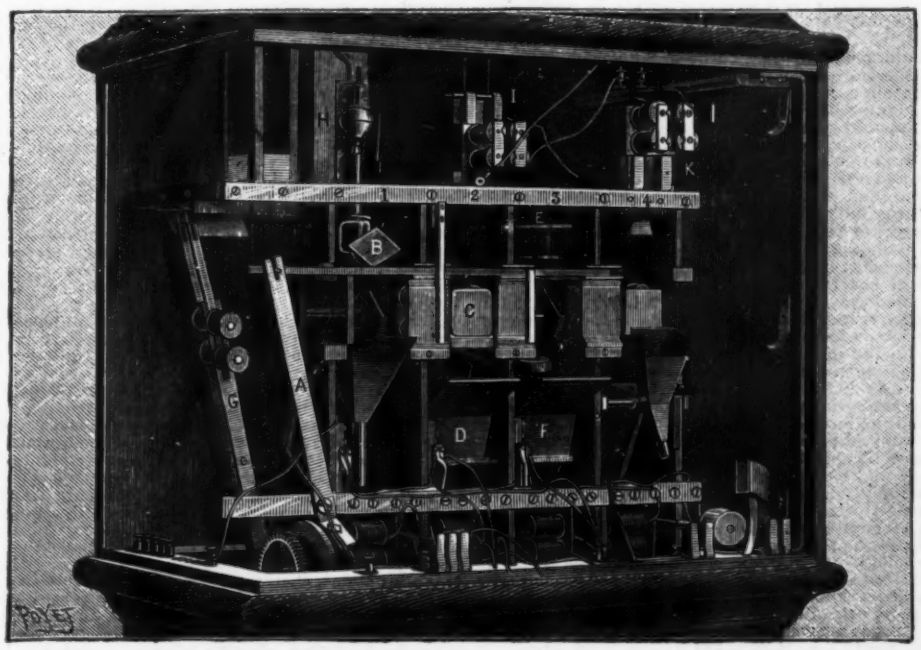


FIG. 3.

A. Lever that actuates the carriage which causes the plates to pass from one compartment to the other. B. Plate at the moment of receiving the collodion. C. Plate in the focus of the objective. D. Nitrate of silver bath. E. Plate at the moment of development. F. Cyanide bath. G. Lever for actuating the apparatus (H) for covering the plate with collodion. I. Electro-magnets for operating the cocks for developing and washing. K. Electro-magnets for operating the alcohol and varnish cocks.

plates are taken up by a carriage and pushed by the first movable support. The carriage on moving back disengages the frame, which makes its exit at the left hand side of the apparatus.

Afterward comes the application of collodion. In a receptacle of constant level, or intermittent fountain, H (Fig. 3), is inserted a drop counter which enters through an aperture in a cover formed of sheet rubber, to prevent evaporation. The filled drop counter is lifted vertically in order to deposit the collodion upon the properly inclined plate.

For these operations, the plate is held by supports which the current converts at the desired moment into electro-magnets. After the plate has been drained and the collodion has evaporated sufficiently, it is seized by a hook and pushed upon the support of the second compartment. It is then plunged into the nitrate of silver receptacle, D, where it remains for one minute. During this period, it is shaken several times to facilitate the cleaning of the collodion. The plate afterward arrives at the place of exposure, C. The exposure is regulated in advance, and as often as circumstances require it, by a triangular piece which recedes from or approaches the center of the commutator, and which prolongs or diminishes the contact of the shutter.

During the entire time that the shutter remains open, a bell, as we have before said, notifies the sitter that he must not stir. After the picture has been taken, the plate is seized by a hook which thrusts it upon the support of the third compartment.

In this compartment it is developed, washed, fixed, and again washed. The gyrating motion of the support brings the plate over a funnel and under a developing cock, always in the direction of the drainage of the plate in order to prevent spots. The cock terminates in a flat rose which distributes the liquid in a flat jet. The water for washing, likewise, passes into the same rose, and, while it washes the plate, frees the cock of any deposit that might remain from the developing bath. The plate is next immersed in the fixing bath, F, of cyanide of potassium, and afterward returns to be washed anew.

In the fourth compartment, the plate is first washed with alcohol and afterward varnished with shellac. It remains for a short time, to dry, over a tube heated internally by a special lamp. The plate afterward enters a flat tube that leads it out of the apparatus.

In this apparatus, it is to be remarked that the successive baths have no influence upon each other, since the plates always move forward and the hooks that make them pass from one compartment to the other never touch any other than the same corresponding baths. After all the operations, the plate drops into a tube that delivers it to the customer. All these operations are performed in five minutes.

Owing to the division of the operations upon the groups and to the system of passage from one compartment to the other, by means of rods peculiar to each

group, there can be no mixing of the products. During their passage from one compartment to another, the plates are held by the attraction of a fixed electro-magnet, and then they are seized by the electros that are upon each movable support.

We have seen that the hands of the external dials indicate at every instant the progress of the operations, but what is most interesting is that, owing to the division of the operations into four groups, it is possible to begin a second picture as soon as the plate has passed into the second compartment, and so on. So, at every given instant, the operations are executed simultaneously in the four compartments, and so on, as long as coins are put into the slot.

By means of a very simple mechanism the cash box indicates of itself whether it can receive more or not. It shows the inscription, "Cash Box Open," or "Cash Box Closed," according as the apparatus can or cannot receive the coin.

This system has a real interest from another point of view. It shows that all the operations are interdependent, and that they can be regulated once for all, on one condition, and that is that the action of the light be always the same. But, as that constantly varies, and we cannot regulate it at our own will, it is the time of its admission that has to be modified more or less, according to circumstances, in order to obtain the same effect. This has been very well realized by Mr. Enjalbert through an arrangement that permits of regulating the time of exposure for obtaining what might be called the normal time. When, in ordinary photography, the day comes in which we shall have an apparatus that will give the normal time of exposure in such or such hypotheses, with such instruments, such preparations, and such development, automatic photography will exist in the true acceptation of the word.

At present, if, in the apparatus described, we use a developing bath that is always identical, it is the time of exposure that must vary, according to the differences in the intensity of the light.

If, on the contrary, we wish to adopt a time of exposure that is always the same, it is in the development that the variants will have to occur.

Finally, what has struck us the most in this apparatus is the talent and ingenuity that have presided in the execution of it. We permit ourselves to congratulate Mr. Enjalbert warmly for his very curious invention, and we hope that our readers will experience as much interest as we have done in the study of this new and original device.—*La Nature.*

THE PHYSICAL PAPERS AT THE BRITISH ASSOCIATION.

PROF. A. W. RUCKER, F.R.S., read a paper on cometic nebulæ. Prof. Lockyer has suggested that comet-like nebulæ may be caused by the passage of a very dense swarm through a stream of meteorites, the relative velocity of the two being very considerable. The author has, therefore, attempted to calculate the increase in the number of collisions which takes place in the rear of an attracting mass which passes through a swarm of meteorites so sparsely scattered through space that the main effects of the attraction are produced in a distance which is small compared with the length of the mean free path. Assuming, with Clausius, that the particles have equal velocities equally distributed in all directions, and which are small compared with the relative velocity of approach, the collisions will be most numerous within a cone the apex of which is the attracting body or nucleus, and which contains the lines which are parallel to the relative velocities of the individual meteorites and the nucleus when at an infinite distance apart. The collisions will increase enormously when the nebulæ come nearer the sun, and will take place about every second at points, in round numbers, 100 miles apart.

Prof. C. Piazzi Smyth, late Astronomer Royal for Scotland, read a paper entitled "Re-examination of the Spectra of Twenty-three Gas-vacuum, End-on Tubes, after six to ten years of existence and use." This inquiry began in an attempt to ascertain, by refined mensurations, whether there was any sensible difference of spectral place for hydrogen lines, when they appeared adventitiously and scantily in tubes of other and very different gases, or in tubes of nothing but pure and abundant hydrogen by original intention. But, after having obtained a negative in every case, the inquirer became more taken up with the *changes* that had occurred in certain of the tubes subsequent to 1880, when he published upon them in the Transactions of the Royal Society of Edinburgh. Thus, a chlorine tube, of which it was printed in 1880 that it was then still showing its chlorine lines, though fainter, after two years' use, while carbon bands and hydrogen lines had begun to appear; yet now, in 1889, it has nothing but hydrogen lines, and in great brilliance, to show. Again, an iodine tube which had a comparatively large quantity of solid iodine granules introduced into, and sealed up in, its interior eleven years ago, and showed then a splendid spectrum of 148 measured iodine lines, extending discontinuously from red to violet, and had nothing else, *save* three very faint puny images of the three principal lines of hydrogen—this tube, in 1889, has not a single iodine line now left; but its spectrum, which is brighter than ever, is composed of nothing but hydrogen lines, so that the once solid iodine granules would seem to be partly deposited on the inside of the tube as yellow haze, besides leaving a trifle of loose dust. The author also mentions with much satisfaction that a London maker, Mr. Charles Casella, transcended all others by supplying him with one tube of CO, two of N, and two of O, which have, through six years of existence and work, shown their respective spectra without a trace of hydrogen.

Lord Rayleigh, Sec R.S., in a paper on the tones of bells, said that observations were made on a considerable number of bells of the usual church pattern. The pitch of the various tones, usually five for each bell, was fixed by comparison with a harmonium and with the aid of resonators. The nominal pitch of the bells appears to depend on the *highest* of the tones recorded. From a musical point of view it would seem that all the bells are far removed from perfection; while the differences of relative pitch in the various cases recorded indicates that it may be possible to effect an improvement even to the extent of bringing all the five tones into harmonious relations. The quality of the sound is, however, very difficult to estimate, and even the imperfect octaves, of which several examples occur, give much less of a dissonant effect than might have been expected.

Captain Abney, F.R.S., read a paper on the quantity of deposit of silver produced by the development on a photographic plate in terms of the intensity of light acting. The author concludes from his experiments that the deposit of silver made by different intensities of light varies directly as the intensity of light acting—this of course within such limits that reversal of the image is not commenced, and that the film is not at any part exhausted of the silver salt which can be reduced.

Lord Rayleigh, Sec. R.S., read a paper on pinhole photography. It was shown, in the *Philosophical Magazine* for 1880, that a simple aperture was as effective as the best possible lens in forming an image, provided only that the focal length (f) was sufficiently great. Conversely, if (f) be given, the aperture may be made so small that the use of a lens will give no advantage; but if the focal length was such as was usually afforded by a camera, the admissible aperture, being very much less than that of the pupil of the eye, is insufficient for reasonably good definition. In some recent experiments the focal length was about 9 feet, and the aperture $\frac{1}{12}$ in. The specimens exhibited were taken upon gelatine plates, and represented a weather-cock seen against the sky. The amount of detail was not materially less than that observable by direct vision in the case of ordinary eyes, but modern plates are so sensitive that there would be no difficulty in working with an aperture equal to that of the pupil, other than that incurred in providing a focal length of 66 feet, with the necessary exclusion of foreign light.

Prof. O. J. Lodge, F.R.S., and Mr. R. T. Glazebrook, F.R.S., read a paper on the determination of v by means of electric oscillations. The authors have recently made a determination of v, using the oscillatory discharge of a condenser. The period of the discharge, which passed between two terminals connected through a circuit of measured self-induction to a condenser of known capacity, was determined by forming an image of the spark on the edge of a rapidly revolving circular photographic plate, the rate of revolution being accurately ascertained.

Prof. A. W. Rucker, F.R.S., read a paper on the instruments used in the recent magnetic survey of France. A magnetic survey of France has recently been completed by M. Moureaux, who has determined the magnetic elements at some seventy stations. Prof. Rucker exhibited a set of instruments recently made under the supervision of M. Moureaux for the Science Museum at South Kensington. The point aimed at in their construction was to secure accuracy combined with dimensions and weight much less than those of the Kew pattern instruments. The main points in the construction are 1, that the needles used are much smaller than those used in the Kew pattern instruments; 2, the end of the declination needle forms a concave mirror, and a reading is taken when the image of a linear mark formed by the mirror is in the prolongation of another line which is exactly opposite to the first on a thin piece of metal; 3, the geographical meridian is determined by a theodolite, which forms part of the apparatus, instead of by using—as in the Kew—a plane mirror to reflect the image of the sun into a horizontal telescope; 4, extremely fine silk threads are able to support the small magnets used; 5, in the dip circle the graduated arc rotates in its own plane about a horizontal axis, and a reading is taken when the end of the needle and its image, formed by a concave mirror attached to the graduated circle, coincide when viewed through a microscope.

Prof. J. A. Ewing, F.R.S., in a paper on the magnetic viscosity of iron, described experiments showing that in certain circumstances the process is gradual by which iron assumes magnetization after the imposition of magnetizing force. The experiments are given in detail in Proc. Roy. Soc., June 20, 1889.

Prof. Everett, F.R.S., read a paper on the relation between brachistochrones and ray paths, in which he pointed out an application of well-known laws of optics to the comparison of the law of force for a free path with the law of force for a path of least time, the path itself being supposed given; and to the closely allied problems of deducing the form of the path of least time from the form of the free path when the law of force is given. Most of his results, he stated, have previously been obtained by means of the principle of least action, but the optical method will be available for many students who have not mastered that principle.

Prof. Cayley, F.R.S., addressed the section on curves in space.

Prof. J. A. Ewing, F.R.S., read a paper on hysteresis in the relation of strain to stress. It is now well known that when an iron wire is subjected to the alternate application and removal of tensile stress, many times repeated, certain of its qualities which are affected by the changes of stress exhibit hysteresis with regard to the changes of stress. If the load is cyclically varied between definite limits, these qualities do not have the same values at corresponding intermediate points during the application and removal of load; there is hysteresis or lagging in the change of quality, and in some cases this appears to be of a static character—that is to say, independent of the time rate of variation of stress. Conspicuous instances of this action are seen in the change of magnetic and thermo-electric qualities under change of stress, some of which have been described by the author in former papers. It is natural to look for an effect of the same kind in the extension and retraction which the wire undergoes. We should expect that, after the change of loads has been frequently repeated so that a cycle *regime* is established, the wire will, for any value of load intermediate between the two extremes, be longer during unloading than during loading. Evidently if such an effect exists it must be small, as it is well known that the proportionality of strain to stress which is expressed by Hooke's law is at least approximately exact. Sir W. Thomson's experiments on the damping of torsional vibrators have long ago shown that an action of the kind spoken of occurs in quickly performed cycles of torsional strain. But it does not appear to have been looked for in slow cycles of longitudinal pull. The author has, with the assistance of one of his students, Mr. D. Low, looked for the effect in question, and has found it, not only in iron, but in steel, brass, and copper wires. He has not yet examined other metals.

The experiment consisted in observing, with much optical magnification, the extension of a very long piece of wire, directly loaded with lead weights. The wire was hung from a rigid support in a testing flue or recess, built in the wall of the laboratory, and extending up through four stories. At a distance of 806 cm. below the top a small clamp was fixed on the wire, and this formed the support of the back foot of a little tripod, the feet of which consisted of three needle points about an inch apart.

The two front feet rested in a slot and hole in a fixed shelf which stood in front of the long wire. The tripod carried a plane mirror which became tilted forward or backward as the wire extended or retracted. Readings were taken by a telescope of the reflected scale of a leveling staff placed vertically at a distance of some 5 meters from the mirror. The staff was graduated to 1/100 of a foot, and it was easy to read by estimation to 1/1000 of a foot, which corresponded to 0·000000102 of the length of the wire. At first a fixed shelf was used to support the two front feet of the mirror, but the effects of temperature were found to be excessive, although the greatest care was taken to shield the wire from draughts; and the plan was resorted to of hanging the shelf from two adjacent wires of the same material, suspended from the same support as the wire which was to be stretched. In this form the arrangement for optical multiplication was nearly the same as one used by Mr. Bottomley in recent experiments on the extension of loaded wires by heat.

Prof. Henry Stroud, in a paper on the E.M.F. produced by an abrupt variation of temperature at the point of contact of two portions of the same metal, gave the results of experiments on the E.M.F. produced when two portions of the same metal are in contact, and one portion is *kept* at a high temperature and the other at a low temperature. The precautions necessary in the performance of such experiments are discussed in the paper, and the results obtained are given in the case of copper and iron. The E.M.F. established in the case of copper is from hot to cold across the junction, while in the case of iron it is from cold to hot, and of far greater magnitude. These experiments are being continued with a view to obtaining the relation between the E.M.F. and the difference of temperature.

Prof. McLeod, F.R.S., in a paper on the black bulb thermometer *in vacuo*, concludes the black bulbs should be as small as possible, and very little of the stem blackened, and also that the case should be as thin as is consistent with strength.

Sir W. Thomson, F.R.S., communicated a paper, by Magnus Maclean and Makita Goto, on electrification of air by combustion. A series of experiments was made, under the instructions of Sir William Thomson, for the purpose of endeavoring to find: (1) the state of the air inside a room as regards electrification; (2) the relation between electrification of air within a building and the atmospheric potential in its neighborhood outside; and (3) the causes which produce or change the electrification of any given mass of air. It was found that an inclosed mass of air is electrified negatively by the burning of a paraffin lamp, of coal gas, of sulphur, of magnesium, and of several other substances; and, on the other hand, the burning of charcoal electrified a room positively.

Prof. C. Michie Smith read some notes on atmospheric electricity and the use of Sir W. Thomson's portable electrometer. Recent observations fully confirm the author's previous conclusions that with a dry, west wind, the potential of the air for some distance above the ground is usually negative. This seems always to be associated with dusty air. In using the portable electrometer in hot, moist climates, special precautions have to be taken in drying it. As much sulphuric acid must be used as the pumice can absorb, and the pumice should be dried at least once a fortnight. The charging rod itself must be very carefully dried, and, after charging, should be lifted out with a piece of warm silk.

Mr. A. W. Clayden read a paper on dark flashes of lightning. The author exhibited a negative taken on June 6 last, which shows several reversed images of lightning flashes. He described a series of experiments which he had carried out with the object of discovering whether the phenomenon could be imitated in the laboratory.

The steps in the investigation were illustrated by a series of negatives showing photographs of electric sparks. The conclusions arrived at are that photographic images of electric sparks can be reversed by the action of diffused light. Reversal is only produced when the exposure to diffused light is subsequent to (or possibly simultaneous with) exposure to the image of the spark. If the plate is first acted upon by diffused light, the sparks give a direct image unless the action has been considerable, in which case they seem to make no impression.

Prof. Cleveland Abbe, in a paper on the determination of the amount of rainfall, gave a *resume* of the general results of investigations on this subject. The deficit in catch by a gauge due to the eddies of wind is shown, on general reasoning, to be proportional to the velocity of the wind and to the relative percentage of small and slowly falling drops.

Prof. C. Piazzi Smyth, late Astronomer Royal for Scotland, read a paper entitled "Hygrometry in the *Meteorological Journal*." After noting the superior value officially attached to determinations of the mean temperature by observations of self-registering thermometers, recording its maximum and minimum every twenty-four hours, the author inquires why the still more difficult problem of ascertaining the mean daily moisture of the atmosphere is thrown over to a different principle of observing, long since condemned for simple temperature. Believing that the want of good self-registering dry and wet bulb thermometers for the purpose was the chief obstacle, and having alighted on some recent makes of Sixe's thermometers with several very recommendable qualities, he invested two out of four of them with the peculiar fittings for wet bulb hygrometers, after having made a table of index corrections for them all, as compared with standard thermometers. But as soon as hygrometric observations began, the depression of the wet, below the dry, bulb always came out at only two-thirds of what a standard but non-registering Glaisher arrangement gave out, for the horizontal form of Sixe, and no more than half for a vertical form. These differences of hygrometric statement, though rather puzzling for a

time, were traced up to the wet bulbs of the Sixe's thermometers being in contact on one side with the scale plate. For when that plate in the horizontal Sixe form was cut entirely away from the bulb, and a new vertical form of Sixe was made (*per* Mr. James Bryson, Edinburgh), with its long thin bulb wholly outside the rest of the instrument, the indications of all three varieties of wet bulb hygrometers became practically the same; and hygrometry was relieved of the old drawback on its registrations of maximum and minimum quantities of moisture in every twenty-four hours.

Mr. F. T. Trouton read a paper on some experiments on radiation with Prof. Hertz's mirrors. These experiments were described in *Nature*, vol. xxxix., p. 391, and vol. xl., p. 398. Certain of them were repeated by Mr. Trouton in the physical laboratory of the Durham College of Science.

Profs. A. W. Rucker, F.R.S., and T. E. Thorpe, F.R.S., read a paper, on the relation between the geological constitution and the magnetic state of the United Kingdom, before a joint meeting of sections A and C. The authors have, during the last five summers, determined the magnetic elements at 200 stations, distributed over the whole of the United Kingdom, and have employed the results of their observations in a study of the disturbing magnetic forces in play in various districts. If all disturbing causes were removed, an observer traveling due west from London would find that the declination increased by about half a degree for each degree of longitude. In fact, the rate of increase, though equal on an average to this amount, is irregular. Between London and Windsor it is considerably larger, and between Windsor and Reading smaller than the mean.

The forces which produce these abnormal variations depend upon the geological character of the district. Two principal theories have been proposed to account for these disturbances: (1) the theory of direct action of magnetic rocks; (2) the other explanation associates the deflection of the needle with disturbances of the earth currents of electricity produced by irregularities in the geological constitution of the country, and especially with geological faults. On the whole, the authors think that the theory of the direct action of magnetic rocks agrees best with the observed facts, and they have shown that the kingdom can be divided into a small number of magnetic districts in which the directions of the disturbing forces are evidently closely connected with the geological constitution.

In a paper on the passage of electricity through gases, Prof. Arthur Schuster, F.R.S., gave an account of his investigations during the last two years on the distribution of potential in the neighborhood of the negative pole of discharge of electricity through rarified gases. Knowing the rate of fall of potential, it can be determined whether there is any bodily electrification in any part of the negative glow. It was found that the kathode is surrounded by an atmosphere of positively electrified gaseous particles extending to the outer edge of the so-called dark space. According to the author's views, this atmosphere corresponds to the polarized layer adjoining the negative electrode in an electrolyte. The cause of the sudden difference in luminosity between the dark space and the negative glow has also been investigated, and it has been found that negative particles projected from the kathode pass unhindered through the dark space, while their velocity is quickly reduced in the glow proper, the translatory energy being thus changed into energy of vibration.

Prof. Oliver J. Lodge, F.R.S., read a paper on the failure of metal sheets to screen off the electrostatic effect of *moving* or *varying* charges. Experiments have been made on the screening effect of a very thin film of silver chemically deposited, the thickness of the deposit being different in different experiments. The silver screens are only found to protect so long as they are opaque; they no longer do so when the deposit is so thin as to be transparent.

Prof. James Blyth described a new form of current weigher. In the construction of balances for the measurement of electric currents, a greater or less difficulty has always been experienced in leading the current into the movable parts of the instrument without seriously interfering with its sensibility. Several methods have been adopted to overcome this difficulty. In some balances the current is led in by mercury cups; in others, flexible leads, made of thin wire spirals or thin metal strips, are employed; while, in the recent balances by Sir William Thomson, the difficulty has been overcome by means of his well known ligature suspension. Some time ago it occurred to the author that still another form of balance might be employed for this purpose, and the present paper is a short description of one which he has made. The balance referred to is of the ordinary Roberval type, with the pivot connections all replaced by tightly stretched torsion wires.

It is constructed as follows: On a flat baseboard are placed two vertical uprights of wood or other insulating material about 6 inches apart. Between these are stretched two parallel wires in the same vertical plane about 3 inches apart. To the middle points of these wires are soldered the two horizontal metal bars of the Roberval. These are about 9 inches long. Both horizontal bars terminate at each end either in forks or rings, placed in a horizontal plane, and wires are tightly stretched between the prongs of the forks, or across a diameter of the rings. To the middle points of these last wires are attached, also by soldering, the vertical bars of the balance, thus completing what takes the place of the ordinary jointed parallelogram of the Roberval.

The vertical bars have metal terminals, insulated from each other, and carry the circular disks, on the rims of which the movable coils of wire are wound. The bars pass at right angles through the centers of the disks, and are fixed to them at their middle points. The middle coils, which are of exactly the same diameter as the movable ones, are supported from the baseboard, and are placed so that one is about half an inch above one movable coil, while the other is as much below the other movable coil. From this it will be seen that, when the balance is in equilibrium, the fixed and movable coils are all horizontal, with a space of about half an inch between each pair. The stretched wires may be either of steel or phosphor bronze, and before being finally soldered are placed under considerable tension.

The current flows through the instrument thus: Entering, say, by the upper wire connecting the fixed supports, it passes to the upper horizontal bar. There it splits into two, one half (supposing the resistances equal) passing to each end of the bar, and, by means of the corresponding fork wires, passing through the movable coils. From the movable coils each half returns along the lower horizontal bar, and together pass out by the lower wire connecting the two main supports. From this the whole current passes first through the one fixed coil, and then through the other, and in such a direction as to produce a repulsion between each pair of coils. In the constructing, care is taken that the suspended coils are both made of equal weight, and that when the balance is in equilibrium no torsion is in any of the wires. Small scale pans are attached to each vertical bar, and a bob for raising or lowering the center of gravity of the whole is placed on a rod springing at right angles from the middle of one of the horizontal bars. The current strength is estimated by the weight needed to restore the balance to equilibrium when disturbed by the passage of the current. A sliding weight may also be used, as in a steelyard. It will be readily seen that, as in all forms of current weigher, the weights are proportional to the square of the current strength.

Prof. S. P. Thompson described a phenomenon in the electro-chemical solution of metals—originally discovered by Plante—which occurs when a current is passed between two copper wires immersed in dilute sulphuric acid in a cell. The solution takes place in two stages, the metal first oxidizing, and then the oxide dissolving in the acid. This was projected on the screen, the audience being able to observe that the bubbles evolved when the current was turned on ceased as the current died down, choked by the formation of oxide, but almost immediately recommenced when the oxide began to dissolve. The author has tried other metals and other acids—silver, zinc, and iron showing similar effects in sulphuric acid, but not in nitric, acetic, or hydrochloric acid.

Mr. J. Wilson Swan read a paper on chromic acid as a depolarizer in Bunsen's battery. When chromic acid became an article of commerce at a moderate price, it occurred to the author to see if he could not obtain a substitute for the nitric acid of the Bunsen battery. As the results of his experiments he finds that a solution, of the composition nitric acid 1 part, chromic acid 2 parts, sulphuric acid 5 parts, and water 5 parts, gives results equal to that obtained with nitric acid.

Prof. Perry, F.R.S., described a variable standard of self-induction. An instrument like that hitherto used as a variable standard by Prof. Ayrton and the author was used by Prof. Hughes. It is a fixed coil of wire, inside which a movable coil is placed; the coils are in series one with another. When their planes are parallel, there is either a minimum or a maximum coefficient. When the movable coil is rotated so that its plane makes various angles with the plane of the fixed coil, a pointer shows on a scale the coefficient for that particular position.

In another paper on a hot twisted strip voltmeter, Prof. Perry described the behavior of twisted strips subjected to axial pull. A small elongation is accompanied by a great rotation, so that these strips may be employed in measuring instruments, such as weighing machines, aneroid barometers, testing machines, etc. For the Ayrton and Perry voltmeter a double-twisted strip of platinum silver with its ends insulated is initially in tension inside a tube or frame two-thirds brass and one-third iron, a pointer at the middle of the strip being visible above a dial and capable of a motion of nearly 360°. When the current passes, the pointer rotates because of the heating of the strip. By continuous making and breaking of a large current through the strip during seventy-two hours all zero and other errors seem to be eliminated. The highest reading of the exhibited instrument was 2½ volts, so that it is particularly useful in accumulator work. The author gave the law of transformers generally, and found that a small transformer on the base of the instrument converted it into a voltmeter of any range whatsoever for alternating currents, the readings being independent of the frequency of alternation. The author exhibited twisted strips of carbon made by Messrs. Woodhouse and Rawson, which he intends to use for voltmeters of higher range.

Mr. W. H. Preece, F.R.S., read a paper on the relative effects of steady and alternate currents on different conductors. Sir W. Thomson, at the Bath meeting of the British Association, stated that alternating currents entered a distance of only about three millimeters into the heart of a thick round copper conductor, when the frequency was 150. This "diffusion law," as he called it, is dependent on the coefficient of self-induction and on the frequency, *i. e.*, on the number of complete alternations of positive and negative currents transmitted per second. As this law has a most important bearing on the commercial value of the systems of distribution dependent on alternating currents, it becomes most desirable to study the question practically. The verification of this law is almost beyond the reach of experiment. It occurred to the author, however, that if conductors of different materials are taken, such as iron, copper, lead, and plantinoid, of easily measurable lengths and of convenient sectional areas, and if measurable and variable currents, both alternating and direct, approximately similar to those used in practice, are transmitted through them, the question could be studied by observing any difference, if such existed, in the total expenditure of energy in the conductors under these different circumstances. The general conclusion to be drawn from the experiments is that practically no serious error has been made in the form of conductors so much used for alternating current systems, and that nothing cheaper or better has been devised than a simple stranded conductor coated with a suitable insulating coating. The experiments do not solve the question of the distribution of current density through the section of the conductor, but they do show that within the range of practice the total flow of energy is the same in copper conductors, whether it be urged by alternate or by steady currents.

Prof. G. Forbes, F.R.S., and Mr. W. H. Preece, F.R.S., in a paper on a new thermometric scale, suggest the joule as the thermal unit instead of the therm or the calorie. 4·2 joules will raise the temperature of 1 gramme of water at 4° one degree, hence to raise 1 gramme of water from freezing point to boiling point requires 420 joules; and it is suggested that the difference of temperature between freezing and boiling points should be represented by 420 units of temperature.

Mr. J. T. Bottomley, F.R.S., exhibited some large Leyden jars, broken during the testing of a large Wimshurst machine which was being constructed by Sir Archibald Campbell, Bart., of Blythswood. They were excellent examples of multiple fracture.

Prof. S. P. Thompson, in a paper on sparkless electro-magnets, discussed the various means of suppressing the sparks in the circuits of electro-magnets. The most effective means, he finds, is to surround the core of the magnet with a substantial shield of copper. The author illustrated his method by experiments before the section.

Mr. W. W. Haldane Gee and Dr. Arthur Harden read a paper on stereometry. This communication relates to the methods used for the determination of the volumes of bodies to which the hydrostatic method is not applicable. The authors have devised a convenient form of instrument, first proposed by Say, and afterward modified by Leslie, Kopp, Regnault, and Miller. They have also shown that the following method for ascertaining volumes is very generally applicable, and likely to be of considerable service in physico-chemical researches.

The body whose volume is desired is inclosed within a vessel of known volume, and then carbon dioxide (or other dry soluble gas) is passed into it for some time. The gas is then displaced by dry air (or other gas), and the volume of the carbon dioxide driven out is ascertained *gravimetrically* by absorption in bulbs containing caustic potash solution. By first filling the vessel with dry air and then driving it out with carbon dioxide, the volume of the air, and hence that of the body, may also be ascertained *volumetrically*, but with less accuracy. The gravimetric method is especially applicable for accurately ascertaining the density of soluble gases. For this purpose it is far more convenient than the process of direct weighing as used by Regnault.

In a paper on the specific heat of caoutchouc, Mr. W. W. Haldane Gee and Mr. Hubert L. Terry described a number of determinations which had been made of the specific heat of Para India rubber which had been masticated, hydraulically compressed, and then cut into sheets from 0·22 millimeter to 1·40 millimeter thick. The rubber was alternated with sheets of tinfoil, and heated for two hours in a steam jacket at 100° C. A modification of Regnault's method of mixtures was employed to find the specific heat of the hot rubber.

Owing to the non-conducting nature of the substance the time of the calorimeter attaining its maximum temperature is as long as ten minutes; hence it has been necessary to apply special formulæ for the correction due to cooling. Those proposed by Pfaundler, Pape, and Schuster have been used, and the results calculated in accordance with them. The mean of the best conducted experiments gives for the Para rubber the number 0·486. The investigation is being extended to allied bodies, especially the different forms of vulcanized rubber and gutta percha.

Mr. F. T. Trouton read a paper on the temporary thermo-currents in iron. If a portion of an iron wire connected up to a galvanometer be heated red hot, and the heated portion be caused to travel along the wire by moving the flame, a current is produced, which is due to the fact that when iron changes its molecular state at the temperature of recalescence, this change does not take place at the same temperature on heating as on cooling, so that when a flame is moved along an iron wire so as to continuously heat it above the temperature of recalescence, the junction of the altered with the unaltered metal in front is at a higher temperature than of the junction behind the flame.

Prof. Barrett read a paper on recalescence of iron.—*Nature.*

PORCELAIN MANUFACTURE IN BERLIN.

NEAR the Thiergarten station lie the buildings of the Imperial Porcelain Factory. They are on Wegely-strasse, which name reminds us of the merchant Wegely, who established the first Berlin porcelain factory in 1750, on the ground now occupied by the Sedan panorama. During the building of the latter the workmen found large quantities of porcelain that had been buried by Wegely at a time when the country was unsettled. This discovery proved that the recipe for the mixing of "arcanum," which was kept a secret at that time and was very highly prized, was of a simple nature and had been greatly surpassed by modern manufacturers. But the "arcanum," for the manufacture of which various porcelain factories (Hochst, Frankenthal, Vienna, Sevres) were established, dates back to the alchemist and inventor of the Meissen porcelain, Bottcher (1709). The manufacture of porcelain must have been a very thankless occupation in his time, for the weather and other causes would often bring about complete failure. In winter no purple could be produced on the ware, and in summer no red light could be used, and besides this the poorly arranged ovens caused great loss. The banker Gotzkowski, the last owner of the factory, offered to sell to Frederick the Great, in 1763, for $146,250. In the contract special attention was paid to securing the "arcanum," and it was agreed that "all secrets, knowledge, arts and processes shall be made known, described, and delivered up to his Majesty." All employes had to promise under oath to conceal their knowledge from all outsiders. The king used peculiar means for promoting the sale of the porcelain. At certain celebrations the Jews were obliged to buy $3,000 worth, and the lottery loan societies were obliged to sell many thousand dollars' worth of the ware in foreign countries.

The manufacture of porcelain is no longer kept a secret in the works, which were moved to Charlottenburg in 1870, and in which Alexander von Humboldt worked in 1852. Kaolin and pure feldspar are the ingredients of the mass used. After the mineral kaolin has been comminuted by means of a large millstone, the powder is placed in an iron drum, where it is ground still finer by granite balls that are allowed to run freely in the drum when it is turned. The cleaning of this powder is of great importance, and on it the success of the whole process depends. It is separated from pieces of stone, coarse quartz, sand, etc., by being passed through an ingeniously constructed system of basins and channels until the kaolin finally settles in the bottom of the vessel; the water is then removed and the

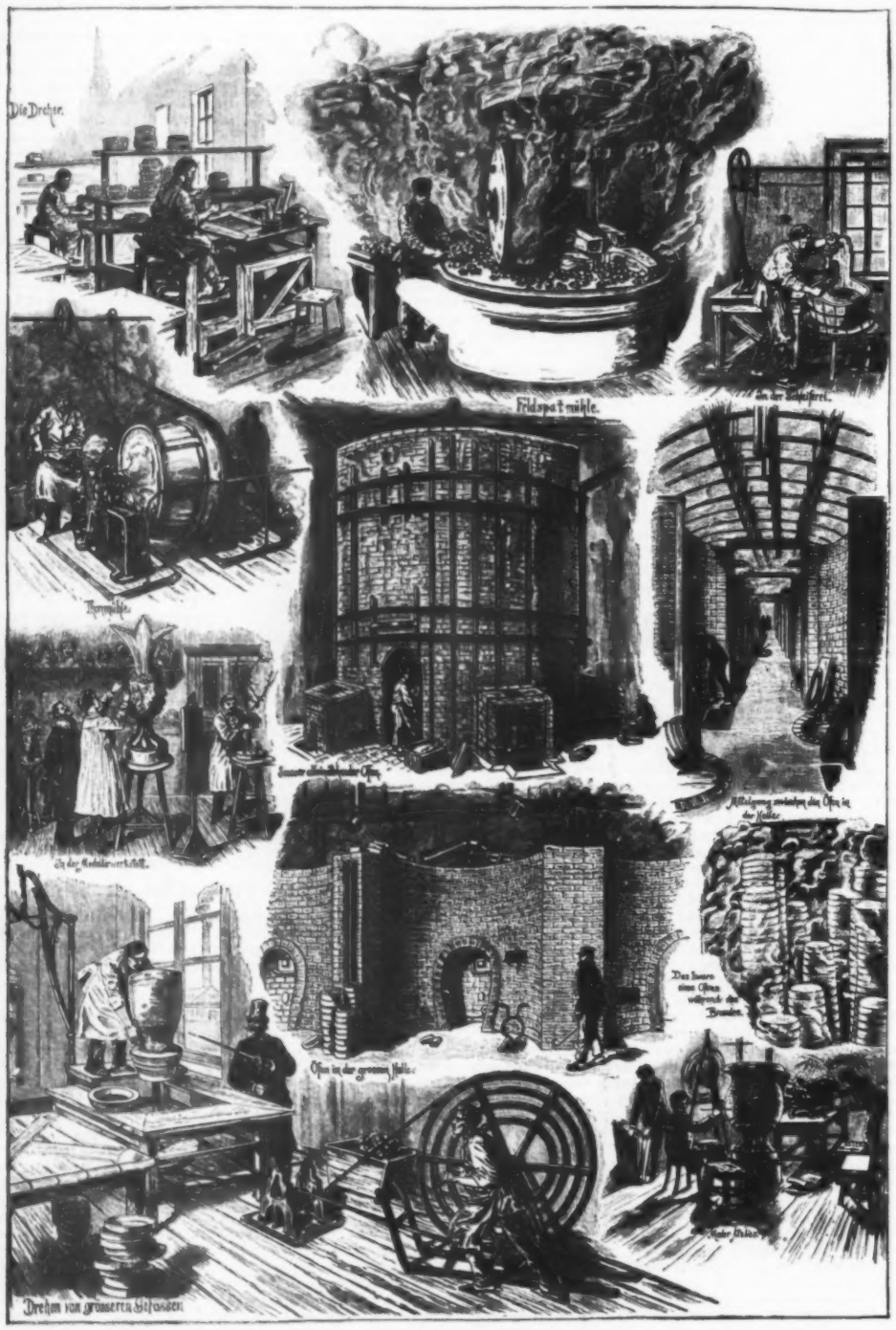
mass taken out, and to it is added a certain quantity of finely ground feldspar. This compound is placed in filter presses, such as are used in sugar factories, where it is made into a plastic cake of the consistency of bread dough. This is thoroughly kneaded and is then ready to be made up into different articles. Large vessels require special manipulation, and objects having many projecting parts, such as figures, statuettes, vases, and jardinaires with handles, plastic ornaments, portions of plants, etc., are pressed by hand in plaster moulds.

The casting process forms another branch of manufacture. The semi-fluid mass is poured into special plaster moulds, which, on account of their hydroscopic nature, draw the water from the porcelain mass. After the removal of the surplus moisture the object is taken from the mould and the seams smoothed down, and it is left to dry. When thoroughly dry it is fired, at a temperature of 1,832° F. All water held chemically or mechanically in the mass escapes, and the mass becomes porous, so that it can be coated with a glaze, for when dipped into a thin, fluid glaze (a mixture of fine quartz sand, koalin, marble, and porcelain) the water enters the pores of the mass and the glaze floating on it remains on the surface of the object. The final firing now follows, during which the porcelain is brought to a temperature of from 3,092° to 3,182°. During the firing each piece is held in a clay casing by which it is protected from the flames.

The artistic part of the work forms an important feature in porcelain manufacture, and the form, color, and ornamentation of the separate articles can be so varied that the powers of those to whom this part of the work is intrusted are allowed full scope. From the time that the factory was established until the present day the rococo style has been preferred, as this avoids straight lines and surfaces which, in spite of all technical inventions, are liable to become warped during the firing. During this latter process each object shrinks one-sixth of its whole mass.

Special difficulty has been found in coloring, as the colors used are often modified in an undesirable manner during the baking. Dr. Heinecke, the manager of the factory, has succeeded in producing paintings in transparent enamel, which has never before been done, and is an invention of great artistic importance. An army of painters and sculptors work under the direction of Mr. A. Kips, whose name is well known in the artistic world of Berlin, and they are assisted by distinguished chemists like the director, Dr. Heinecke, and Dr. Kupall.

The products of the Berlin porcelain factories received well deserved recognition and praise in the exhibitions at Copenhagen and Munich on account of their technical and artistic execution. Orders come from all parts of the civilized world. Since the time of Frederick the Great, all Prussian monarchs have given the manufacturers opportunity to make this porcelain well known in foreign parts, and Emperor William II. has followed this custom.—*Illustrirte Zeitung.*



PORCELAIN MANUFACTURE IN BERLIN.

THE THORNEBURRY MINER'S SAFETY LAMP.

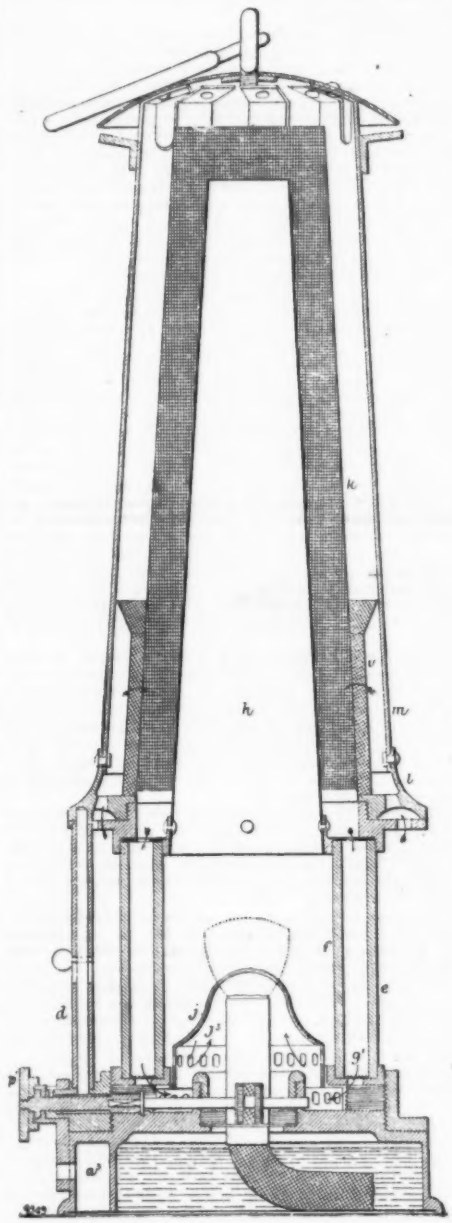
THE fuel of the lamp is heavy petroleum oil having a flashing point of 250 deg., and it is burned under a cone of the familiar form which obtains in paraffin lamps. The whole of the air supply is delivered into this cone, and most of it passes through the slot in the top, making a sharp draught which steadies and brightens the flame. The illumination afforded is from 1 to 1¼ candles, or three to four times that of a modern safety lamp, a most valuable feature, as the miner's ability to detect dangerous spots in the roof depends to a great extent upon the amount of light at his command. The wick can be raised and lowered by a pinion and milled disk in the usual way, but as the gas given off by the oil does not burn in actual contact with the wick, the latter needs very little adjustment and need not be disturbed for hours.

Referring to the illustration, it will be seen that the oil reservoir forms the base of the lamp, and is screwed into the ring, *b*. This ring is connected to an upper ring by a number of columns, *d*, one only of which is seen in the view. Between the two rings there are fixed two concentric glass cylinders, *e* and *f*, so secured that they are not disturbed when the lamp is taken to pieces for cleaning. To the top of the upper ring is screwed the chimney and its case. The air to support combustion enters through holes in the upper ring and, passing the gauze screen, *v*, travels downward between the two glass cylinders, *e* and *f*. At the bottom it passes through a ring of gauze, g^1, and then through perforations in the base, *b*, after which it enters the cone. The products of combustion rise up the chimney, *h*, and escape through openings at the top of the case, first passing through the gauze cone, *k*. This latter, however, is not necessary for safety. The lamp is self-extinguishing in an explosive mixture, the gas and air entering the lamp cone being ignited by the flame and consumed before it reaches the chimney. Both the lamp flame and the ignited gas are automatically extinguished by the after damp or carbonic acid gas, which is produced in the cone by the ignition of the explosive mixture. Hence it is obvious that the outer gauze inclosing the chimney is not necessary for the safety of the lamp, but is only an additional protection in case of an accident to the bottom gauze ring.

The top part of the lamp is locked by a bolt which stands over the pin, *p*. So long as the latter is in position, the bolt cannot be withdrawn. The pin, *p*, is again locked by a bayonet joint having a part which can be padlocked or riveted to the oil reservoir. When the locking is complete, the lamp cannot be opened without detection by any ingenuity.

The lamp has been tested by Sir Frederick Abel and Professor Dewar, who report that they have conducted a series of laboratory experiments with it, and have witnessed practical trials, which were carried out at the Aldwarke Main Colliery by Mr. Rhodes, in an apparatus of the same character as was used by the last royal commission on accidents in mines. They saw the lamp tested in explosive gas mixtures, the velocity of the current being in some experiments as high as 50 ft. per second, or 3,000 ft. per minute; both horizontal and inclined currents, upward and downward, were used. In all instances the lamp was extinguished within a very few seconds after the explosive gas current was established, and on no occasion during the course of the experiments was the combustible gas mixture within the lamp seen to burn. The lamp, therefore, fulfilled the conditions, even under abnormal circumstances, essential to safety in mines, as laid down in the mines commissioners' report. A light of uniform power, which could be so regulated as to equal from 1 to 1¼ candle power, was maintained for many hours with mineral oil of high flashing point, which, in regard to safety, is not inferior to the animal or vegetable oils used, or to the mixture prescribed by the mines commission.

In regard to simplicity of construction the lamp compares favorably with many of the later and more efficient forms of safety lamps, and the several parts are



THE THORNEBURRY MINER'S SAFETY LAMP.

readily maintained in a thoroughly clean and efficient condition.

The lamp, as at present constructed, is somewhat larger and heavier than the more modern lamps in use. At the same time there are lamps, especially electrical lamps, decidedly larger and heavier than the Thorneburry lamp.—*Engineering.*

THE PLANCHETTE TABLE.

PLANCHETTE is now very seldom met with, and so many questions are constantly sent to the office of this paper concerning it, that we reproduce herewith an illustration of one which appeared in the SCIENTIFIC AMERICAN in 1868.

Many think that there is some hidden secret in the construction of planchette. This, however, is a mistake, as all that is necessary is that the parts should be nicely joined, and that it should stand firmly and move readily on its legs. Any one with ordinary mechanical skill can put one together, and the accompanying cut shows clearly all that is necessary—a heart-shaped cedar board, with two nicely turned metal legs, carrying well lubricated casters, the point of the board having an aperture of suitable size for the insertion of a lead pencil, which serves as the third leg and rests on the paper.

It is not to be supposed that planchette will yield at once to the influence, for it is very willful, and often, when it does begin to move, simply speeds across the paper, scribbling incoherences. One of the most extraordinary traits of planchette, however, is the way in which it will persist in writing repeatedly a meaningless reply, until suddenly the humor will seize it, and it will write a coherent word or sentence. Planchette first made its appearance in 1867, and was by no means slow in attracting almost universal attention. The pranks that it was made to play were so many and curious, and its ways so mysterious, that not only did it become the nightmare of the superstitious, but it afforded amusement in many a household. It became also the subject of investigation by some scientists. Marvelous tales were told by the credulous about it, and planchette often told curious tales about itself. Even as distinguished scientists as Prof. Tyndall and Prof. Faraday were drawn into controversies concerning it.

Many believed that humbug was stamped over every movement of planchette, and that one or the other of those whose hands bore upon it always conspired with the little board in the formulation of its replies; but when it became evident that planchette would write coherent answers while under the influence of those who were in ignorance of the replies that were expected, it became necessary to explain the phenomenon on some other basis. Whether this has ever been satisfactorily answered is in the minds of some still a question. Certain it is that planchette has performed some curious feats, and has made for itself a position in the world of mysteries.

Probably the most generally accepted explanation is that advanced by Lewes and others, that although there is no intentional movement of the hands of those who are subjecting planchette to the influence, still there is, in spite of this, an unconscious pressure of the finger tips upon the board, which directs the movement of the pencil. Nor does it seem that such can be at all unlikely, for unconscious movement is by no means an unusual phase of our existence. The somnambulist who nightly takes a promenade from cellar to garret, or whose steps by chance have led him to the border of a precipice, has as little knowledge of the peril he has escaped when the morning beams have awaked him as planchette is conscious of its movements. How often also in mercantile pursuits do those who are accustomed to a certain routine perform it unconsciously, and after the work has been finished would be unable to tell you of many of the details of the work which custom has taught them to perform correctly, even while in a state of abstraction. Much has been said at times of planchette's prophetic nature. Under the influence of certain people of a highly nervous temperament, or having to a certain extent the qualities of mediums, future events are said to be foretold. Secrets of which the person touching planchette is in ignorance have been divulged in a remarkable way, and many anecdotes draping planchette in mystery are repeated and believed.

Were the testimony, however, more universal, were planchette more consistent, and were it more generally truthful and less given to uttering remarkable sayings only occasionally, there would be more reason for according it a place for thorough and systematic investigation. Perhaps the day will come when mesmerism is understood and mind reading is more satisfactorily explained, that there will be occasion for looking upon planchette more seriously, and of regarding it as a wonderful means of displaying a rational nervous action independent of conscious mental cerebration.

THE PHILOSOPHY OF LIFE.

BY way of complement to his tractate, "Kritische Grundlegung des Transcendentalen Realismus," Dr. Eduard von Hartmann, the author of the "Philosophy of the Unconscious," has just published another pamphlet, entitled *Das Grundproblem der Erkenntnisstheorie* (Leipzig, Wilhelm Friedrich). In it he thoroughly examines and sifts the arguments in favor of the various forms of idealism, and demonstrates their inferiority, as working theories, to that of a reality lying behind the impressions produced upon the senses and transcending their immediate perception. This theory Dr. Von Hartmann calls "transcendental realism," by way of distinction from the crude realism of the untutored mind. His conclusion practically coincides with that of common sense, and yet it is interesting to note how good an argument can be made, upon the facts, in favor of idealism.

Almost every one, unless his attention is specially directed to the point, habitually confounds the impressions made on his senses by the objects with which he comes in contact in daily life with the objects themselves. He looks at a tree, and thinks that he sees the tree; he hears the sound of a bell, and has no doubt that he hears the bell itself ringing; he touches a table, and fancies that its smoothness and hardness reside in the wood or marble of which it is composed; he tastes sugar, and attributes to it the sweetness which he perceives in it; he smells a rose, and in like manner ascribes fragrance to it.

Indeed, it would be as difficult to convince most people that shape, color, sound, hardness, smoothness, sweetness, and fragrance are not qualities of the objects which awaken these sensations, and that the objects themselves are not directly perceived by the mind, as it was for Copernicus to convince his contemporaries that the sun stands still and that the earth revolves on its axis. Yet, what we see when we look at a tree is not the tree itself, but the image of the tree on the retina of the eye, and without the aid of our other senses we should not know whether it was big or little, round or flat, close at hand or afar off.

Every infant has to learn by the use of its hands whether the objects presented to it are within its reach or out of it, and it cries for the moon as readily as it does for an orange. The idea of three-dimensioned space comes, in like manner, only by education, and, until it is attained, all objects appear without perspective, just as they do in Chinese pictures. This was the case with the youth to whom, at the age of twelve, the famous Dr. Cheselden gave for the first time by a surgical operation the faculty of sight. It was a long while before he acquired the ability to judge by the eye alone of the forms and distances of objects. He could not even distinguish a dog from a cat, until, by feeling of both, he had associated the information desired through the sense of touch with that yielded by sight. So, when we say we hear a sound, what we call sound is merely the effect produced upon the drum and nerves of the ear by the vibrations of the air or other sonorous medium, and touch, taste, and smell are likewise nothing more than results produced within our own organism by the sensation-bearing mediums which connect our nerves with the sensation-producing objects.

The world around us is, therefore, really a world within us, which we have learned to project out of ourselves and to create by the use of our thinking faculties. The first European philosopher of note who pointed out this dependence of our conception of an external world upon the ideal world within us was Bishop Berkeley. In opposition to the popular belief, he maintained that the objects of sense, as we apprehend them, are nothing but thoughts, either in our

PLANCHETTE.

own minds or in God's mind. Hence he also maintained that what is commonly called matter is really a thing constituted by our own impressions, and that the mattter of which we infer the existence from those impressions is unreal and imaginary.

By many people, in his own time, he was misunderstood, as he still is in ours, and he was supposed to assert that all visible objects are but the temporary products of human thought. Thus Boswell relates that Dr. Johnson, after a dispute with a Berkeleian, said to him as he was going away: "Pray stay, sir, or else we may cease to think of you, and then you will cease to exist." The author of "Through the Looking Glass" in like manner makes Alice's conductor tell her not to awaken the red chess king because he was dreaming of them, and if he ceased to dream they would cease to be. Berkeley would have answered Johnson by reminding him that it is God's thinking and not man's alone which keeps the universe in existence, and, indeed, he claimed as the pre-eminent merit of his theory that it made a God the necessary foundation of all things.

Berkeley's idealism has nowadays no considerable support among thinkers, either in this country or in Great Britain, but recent advances in science have furnished new arguments in its behalf. The atomic theory suggests that the ultimate particles of which the universe is composed are, after all, nothing but mathematical centers of a force which, in its various modifications, produces upon us the impression of the qualities which we attribute to matter. The table on which I write, solid and hard as it seems to be, is but the condensation of invisible particles, which, by the application of sufficient heat, could once more be resolved back into their original form, and which, upon the removal of the pressure of the atmosphere, would become attenuated to the rarity of the interplanetary ether. The same thing is true of all the substances of the universe. In their last analysis they are nothing but aggregations of extremely little points. The most compact and solid of them are full of pores, and if they could be sufficiently magnified to the eye, they would appear like sponges, if not like the scattered stars in the heavens.

It is customary, too, to speak of matter in general as one thing and of its qualities as another, and to call it in contrast with its qualities as inert or dead. This, however, is a pure metaphysical inference. If such inert or dead matter existed, it could not affect our perceptions, and, therefore, it could not make itself known to us.

All we can learn of what we call matter is the way in which it acts upon us, and therefore all that we have a right to attribute to it is this power of acting upon us. There is no need of supposing anything to underlie such a power or conglomeration of powers, and, therefore, the latest scientific view of atoms tends to represent them, as we have said, as mere centers of force. Every day, too, the doctrine of the correlation or transformation of forces is becoming more firmly established, and promises ultimately to develop into a belief that there is but one primal original force, of which all others, and, consequently, all forms of matter, are modifications. In this aspect the universe becomes dissolved into a fleeting, changing, vapor-like illusion, which is as far as possible from the solid, permanent structure it appears to be to the uninstructed mind. While thus, on the external or physical side, the world may be viewed as only incorporeal force, on the internal or psychological side—that of our own minds—our impressions of it refer themselves back to an unknown and inscrutable center, of which no more can be said than that it exists.

When an image is made upon the nerves of the retina by the reflection of rays of light from any object, it is not the retina which becomes conscious of the image. That organ merely receives the impression made upon it and transmits it along the nerves to the brain. The brain, in turn, does not originate an idea, it only records the modifications to which it is subjected. There is something still behind the brain in which consciousness originates, but what that something is, and how it receives impressions through the brain, is unknown.

In common parlance, it is the soul which feels and thinks, but the existence of a soul apart from the body is neither scientifically nor philosophically demonstrable, and the method by which, if it existed, sensation could be communicated to it is not conceivable. Every part of the human frame of which by any possibility we can become acquainted is also, like the external universe, a conglomeration of points of force arranged in various modes, and, as an object of thought, no more solid and substantial than other objects. Turn and twist in any way we choose, we come back to this result, that the only real thing in the world is pure force, in some one of its innumerable manifestations. This is substantially the view of the ancient Hindoo philosophers, who taught the only reality in the universe is Brahma, or the creative power, and that all else is Maya, or illusion.

Another error from which we need to be delivered is that of the permanence of the world which surrounds us. Time itself is only an appearance resulting from the succession of events within our own experience. We measure it by the revolutions of the earth upon its axis and around the sun, but the portions of it which, thus measured, are equal to one another seem long or short to each person according to his individual nature. Within the memory of man the mountains, the rivers, and the seas have remained substantially unchanged, yet they are continually suffering slight metamorphoses, and in the countless ages of which we have no historical record they have come and gone like the scenery of the mimic stage. The threescore and ten years of human life seem a great deal, yet it is but a handbreadth, as the Psalmist says, and in the sight of the Infinite a thousand years are "but as yesterday when it is past and as a watch in the night." Equally transitory are the products of human exertion.

Men devote centuries to building up great cities, which in succeeding centuries fall to ruin and disappear. Kingdoms and empires are created with great effort and at the cost of countless lives, only to be disintegrated again and blotted from existence. Every summer's harvests and the fruit of every year's industry are consumed almost instantaneously, to make way for new harvests and new industrial products. To a beholder freed from the limitations of time and endowed with the power of seeing all events pass before him in rapid sequence, this globe would be a mere soap bubble, rising up as it were out of nothing, and perishing almost as soon as it came into being. A man's life would be but the flitting of a cloud across the sky, and the succession of nations like that of the waves of the sea.

This being so, the question suggests itself: Wherein do our waking lives differ from our dreams? In dreams we think and feel, act and suffer, precisely as we do when we are awake, and with the same conviction of the reality of our experiences. We speak to other persons and hear them speak to us, we experience emotions of pleasure and of pain, sometimes more acutely than we do when we are awake, and, occasionally, we even debate with ourselves whether we are awake or asleep. If it were possible for us at the close of each day to forget all that happened during that day and to begin life every morning without any connection with the day before, it would be well nigh impossible for us to decide when we were dreaming and when we were awake. It is only the connection supplied by the memory which furnishes us with the criterion and gives us the idea of continued individual existence, but this applies merely to the duration and not to the quality of our sensations. Those of dreams are as vivid and real as those of wakefulness, and when we call these real and the others unreal we make a distinction which applies not to ourselves but to the world around us.

It is not surprising, therefore, that meditative, poetical, and religious minds in all ages have formally entertained the doctrine of the fleeting unsubstantiality of the universe. As has already been mentioned, it lies at the foundation of the Brahmanic philosophy, upon which in turn rests the religion of many hundred millions of human beings.

Job says of man that "he cometh forth like a flower, and is cut down; he fleeth also as a shadow, and continueth not." The Psalms are full of similar sayings, and so are the poets. "Pulvis et umbra sumus," we are dust and a shadow, sings Horace. Shakespeare tells us that "we are such stuff as dreams are made of, and our little life is rounded with a sleep." "This world is all a fleeting show, for man's illusion given," echoes Tom Moore. "Life is a watch, or a vision, between a sleep and a sleep," writes Swinburne, and Sir Alfred Lyall puts the idea thus:

Is life then a dream and delusion, and where shall the dreamer awake?
Is the world seen like shadows on water, and what if the mirror break?
Shall it pass as a camp that is struck, as a tent that is gathered and gone
From the sands that were lamp-lit at eve, and at morning are lev and lone?

Against this purely poetical and sentimental view of the subject robust common sense rebels, and insists that the world is a solid and permanent reality. "Thus do I refute them," said Johnson of the Berkeleians, kicking a stone that lay in his path, as he was walking with Boswell. But the refutation is not so philosophical and conclusive as it seems, for it still leaves open the question whether, after all, the stone with its weight and hardness is not equally with the foot a fiction of the mind.

All that can be said without danger of contradiction is that the healthy human intellect postulates realism as a necessity of its thinking, and the suggestion of Dr. Von Hartmann that, while the appearances of things are only appearances, there lies behind them a transcendental eternal reality, which makes them, for us, as permanent and as substantial as we ourselves are, is a plausible reconciliation of the conflict of opinion on the subject. His treatise is thorough and exhaustive, and we commend it to the attention of the thoughtful.—*N. Y. Sun.*

GEOGRAPHY.*

By Col. Sir FRANCIS DE WINTON.

GEOGRAPHY has not inaptly been defined as "the science of distributions," and from whatever aspect we view it, whether from a large and comprehensive basis embracing all the conditions which surround it as a science, or from the narrower limits of simple physiography, we find certain well-defined principles, or one may term them natural laws, pervading everywhere, whose actions have, through their influences on the past, created the present, and, according to the uses we now put them, must largely govern the future.

The formation of our globe, unfolded to our vision by scientific discovery, brings us face to face with Nature in all her awful grandeur; and we learn how, under a beneficent and all-wise Providence, this world has been fashioned and made for the use of man during periods of time almost beyond man's calculations; and in the history of man upon earth—a mere drop in this ocean of time—we read of the rise and fall of nations, of great wars, of the discoveries of new routes (so ably described by my friend and talented predecessor in the address delivered by him in Section E last year), and we see what large and important developments have taken place as regards the commerce and trade of the world by the effect of these influences; and then, turning to more recent days, we enter upon the discovery of steam, and its application as a motive power—a discovery which has given rise to extraordinary changes, changes by which the whole trade of the world and its industries have been stimulated and promoted.

Add to this the inventions in electricity, by which almost instantaneous communication has been established to all parts of the globe, and we may well cease to wonder at the increase that has been manifested in what may be termed the motive power of the world, and the development of its larger activities.

Still the natural laws which govern this globe, in their relation to the science of geography, remain the same.

It matters not how rapidly you travel from the pole to the equator, you will freeze at the one and perspire at the other; and while passing through the different zones of temperature lying between these regions—the frigid, temperate, and torrid zones—you will find each with its own products, varying with climate, soil, and peculiarity of position, and these variations pervade the whole realm of nature.

Take man as an example: with all his power of brain and reason, he is largely subject to his environment. Look at the toiling millions of the temperate zone, and the enormous activity they display, both mental and physical.

Note their color, form, nervous development; and then pass into the tropics, and the whole creature is changed; he is different in color, and displays none of the energy or brain power of the white species of his kind.

Why is this?

It is chiefly due to the environment in which the creature is living.

The effect of climate upon race is somewhat remarkably illustrated in recent times by noticing the physique and nerve power of the present race of Americans. The wonderful tide of emigration which has raised them to being a nation of 60,000,000 people may have exercised certain influences as regards this change; but there are many true Americans still in existence.

Two hundred years ago they were the same race as ourselves, but the difference between us now is marked. The climate of America has given them an individual stamp, and a perceptible difference in outward semblance has shown itself even in this short space of time.

Similar changes are manifested throughout the whole animal and vegetable kingdom; and while the geologist, zoologist, botanist, ethnologist, and entomologist each and all are separate branches of science, yet each and all have a common ground in geography and its application to the shape and form of land and sea; to the wrinkled folds of the earth's surface which we call mountains and valleys; to the mighty ocean with its currents of air and water, and the influences they exert; to the huge inland seas and lakes; to the great rivers and small streams; to the endless varieties in the animal and vegetable kingdoms; and we find these great elements of nature contributing each in its own sphere to questions relating to the commerce of the world and the development of new countries.

In this brief introduction to my paper I have designedly, though very briefly, drawn your attention to the science of applied geography before passing in review the most recent explorations and discoveries of the present day; and while doing this, I shall endeavor to draw attention to the great necessity for a more thorough study of this science, and the influences it exerts upon trade and commerce, as we gain a better knowledge of the products of one country and the industries of another, as well as the importance of such knowledge to the great manufacturing centers of this nation as new countries are discovered and developed.

It must be remembered that we no longer enjoy a monopoly of trade. Other nations are exhibiting large commercial activities, and if we desire a continuance of the trade of Great Britain, we must put our shoulders to the wheel with the same energies and creative power that have produced such astonishing results during the present century.

CENTRAL ASIA.

In the paper to which I have already alluded it was clearly shown how largely the rise and fall of the great emporiums of commerce in the past centuries were influenced by the struggle for the Eastern trade.

This struggle is still going on. The Russians in Central Asia are steadily advancing as each year goes by, and developing that system of absorption which has characterized their policy, especially in that region.

Central Asia is the chosen field of their explorers, and the recent decease of General Prjevalsky has been a great loss in the scientific world.

A full account of his remarkable discoveries and explorations appeared in the proceedings of the Royal Geographical Society.

The principal work accomplished by the latest Russian explorers, Messrs. Grombchevski, Mr. Lidsky, and Mr. Grum-Grijmailo, in Central Asia, have been in the region of the Pamir, and from thence across the Hindu Kush into Hunza. Also in Eastern Bokhara and in the upper waters of the Yarkand River, the Kalik Pass, and Kanjat.

In the prosecution of these researches, which are all dangerously near our Indian frontier, very full reports are made, more especially as regards trade and commerce; and there is no doubt, since the completion of the Transcaspian Railway to Samarcand, a great impetus has been given to Russian trade in Central Asia, even extending, by well known routes, as far as the northwest provinces of China, where Russian goods are now found entering into competition with those of English manufacture.

By means of this railway, right into the heart of Asia, Russia has obtained the trade of a vast area which formerly passed entirely through British hands. Both politically and commercially she is our rival in the East, and the question which nation is to be supreme must come sooner or later.

CHINA.

There is no more interesting country in the world than China. Her teeming and industrial population, her large mercantile centers, the geographical situation of her territory, her undeveloped mineral wealth, her individuality, and the magnitude of her trade with this country, all combine to invest her with a peculiar importance as regards our mercantile community. Coal has been discovered in all the seventeen provinces of the Chinese empire, but the passive resistance offered by her rulers and her peoples to all attempts by foreign nations to obtain a footing in the interior have prevented any development of her resources. The day, however, cannot be far distant when railways, some of which are already projected, will open up the interior of China and make her better known; but we should be unworthy children of our forefathers if we permit the trade of this rich and widely peopled country to pass from our hands, either from a want of energy or from a departure from those principles of trade and commerce whose foundations are built upon the rocks of integrity and honest dealing. Nothing marks the individuality of the Chinese more than that, wherever you meet him, whatever his surroundings may be, he is John Chinaman still; he never adopts the dress, manners, or customs of other nations, but he remains constant to the pigtail, the quaint dress, and the umbrella; and if established in communities, you will find him with his joss house, food, theater, and his refreshment places just as if he were in China.

BURMAH AND INDIA.

Our knowledge of the latest acquisition in the East, Burmah, has been largely increased during the past eighteen months. Important surveys in northeastern Burmah by Colonel Woodthorpe, R.E., and Mr. Ogle have opened up an area of about 1,500 square miles; and the fact of practicable routes between Assam and Burmah *via* the Palka Pass is now established. Burmah, with its large and intelligent population (numbering about 4,000,000), with its valuable minerals and precious stones, with its tropical products, is well worthy of the attention of the merchant adventurer; and as our knowledge of the physiography of the country is rapidly increasing, a study of its applied geography is strongly recommended to the student.

In our own territory of British India large and important surveys have been carried on under the able direction of Colonel Thuillier. These surveys are conducted in what is called the protected region; but very interesting additions, especially to the merchant, are made in the outlying territories bordering upon our Indian empire, where no white man could go, by the employment of intelligent natives especially trained for the purpose. The information obtained by these men may be very profitably studied.

NORTHERN ASIA.

These central Asian problems are full of deep significance to those desirous of developing and retaining the supremacy of the trade of this empire in those regions; and I am happy to state that papers full of interest on these subjects will be presented to you during this meeting.

Turning to the northern parts of Asia, I feel some diffidence in speaking before a Newcastle audience on the subject of Siberia, for through your own townsmen, and Captain Wiggins, you are well acquainted with these regions. The exertions made by Captain Wiggins and those connected with him in this enterprise should receive the highest commendation; and that they have been so far successful is a matter for rejoicing. At the same time, I cannot but think that Russia, continuing the policy she has so steadily pursued for some years past against the commercial development of Great Britain, would not object to the employment of British capital in opening up trade in her outlying dominions; for that trade, once fairly established on good business lines, would be absorbed on behalf of her own manufacturers. I do not attach any blame to Russia in this matter, but I am of opinion that more profits are to be gained when trade follows the British flag, for then British enterprise and money reap more certain reward. If the energy, talent, and perseverance which have been exhibited by Captain Wiggins and his partners had been utilized in the development of some of our own territories rather than in the territory of another nation, I feel sure they would command that success to which they are so justly entitled.

GREENLAND.

From the consideration of Siberia and the northern seas it is not a far step to Greenland, whose icy regions and eternal snows have been crossed for the first time in our history. The hero of the exploit, Dr. Frithjof Nensen, is a native of Norway, and the exploration which he has so recently conducted to a successful issue was highly alluded to by the president of the Royal Geographical Society, in his annual address, as the most conspicuous achievement of the year.

Though young in years, Dr. Nansen proved himself to be a leader of men, and the account of his adventures will be found to be full of interest. The results of his expedition deal rather with the world of science than with commerce, as his discovery proved Greenland to be nothing more or less than a continent whose interior is a huge region of ice and snow. It, however, presents a most interesting study to those desirous of advancing our knowledge of glaciers and the glacial period. Dr. Nansen's description of this immense mass of frozen snow, forcing its way coastward from the higher plateaus of the interior, by sheer weight and pressure, grinding, crushing, resistless in its slow but ever moving power, gives one a faint idea of how the hills and valleys of the world were formed when, in remote periods of time, they, too, were under glacial influences.

NORTH AMERICA.

Crossing from Greenland to North America, we still find ourselves in regions where ice and snow hold undisputed sway for a considerable portion of the year. The Canadian government, with commendable activity, keep pushing forward their surveys into what is known as the old Hudson Bay Territory. The Mackenzie River has been found to be a far larger body of water than formerly supposed. More accurate surveys as regards the size of some of the great lakes of those regions are being made, and our knowledge of the climate and the isothermal variations of British North America is each year increasing.

Petroleum has been discovered, and, as the geological surveys advance, other discoveries of an important nature may reasonably be anticipated. I have been told of the existence of a huge bed of porous sandstone, saturated with mineral oil, which burns like coal.

Moving southward, we pass through the prairie lands of the northwest of Canada, traversed by the Canadian Pacific Railway. These rich lands are being rapidly developed, and should form a happy home for some of our surplus population. Colonization is a subject full of geographical considerations, but it demands a special paper, and I have neither space nor time to introduce it into this address. At the western edge of these prairie lands are the Rocky Mountains, in whose foot hills are now being reared large herds of cattle and horses, as well as flocks of sheep. Some cattle from these fertile regions were shipped last year to the English market, and no doubt a regular trade will soon follow this experiment.

Crossing the Rockies in a westward direction, you come to the Selkirk Range, then to the Gold Mountains, and lastly to the Cascades, whose wooded rocky sides plunge into the Pacific. Constant explorations are being carried on through these mountain ranges, chiefly in researches after gold and other precious metals, and our knowledge of their physiography is rapidly increasing. The Rev. Mr. Spotswood Green, in an interesting paper concerning these regions, tells us something of the configuration of the Selkirk Range, which offers alike to the mineralogist, sportsman, and Alpine explorer a field of great interest.

MEXICO.

Continuing southward, we pass through the fertile plains and valleys of California, whose large industries in grape and orange culture are being fostered and developed. And from California you enter into Mexico, whose wonderful mineral resources are receiving a new impetus by the construction of railways, 4,700 miles of which are now open to traffic. These railways will not only facilitate the transport of the wealth of Mexico from the coast to the sea, but they tend also to promote law and order among its restless and lawless population. As law and good government are established, so will trade and commerce and the natural riches of the country be promoted and encouraged.

SOUTH AMERICA.

Crossing over to South America, we find considerable progress in commercial activity, chiefly due to the increased means of communication.

In the smaller republics upward of 1,500 miles of railway have been recently constructed; while in the larger states, Brazil has 6,000 miles; Peru, 3,000 miles; Chili, 1,630; and the Argentine Republic, 4,700—making a grand total in South America of 17,000 miles of railways. This allusion to railways may not be considered as bearing on the science of geography, but railways are very important factors as regards the commerce and trade of the world, and by the facilities they afford they largely increase the power of exploration.

The southern portion of South America has been described by those who have visited and explored its savannas and prairie lands as possessing one of the richest grazing lands of the world, and its development is only a question of time. In its present condition it offers a very interesting field of research to the explorer.

Time does not permit us to dwell long on the islands of the Pacific. Recent events concerning Samoa are fresh in your memories, and while some of these islands have developed commercially, it is when they lie in the great ocean tracks of the world that their real importance is manifested. Take, for example, the island of St. Vincent, of the Cape Verde group. It is nothing but a barren rock, without any produce whatever; all its water has to be brought from a neighboring island; yet it pays a large revenue to the Portuguese government simply from coal dues, for it has a good harbor and lies directly in the line between Great Britain and the principal ports of South America; it has, therefore, become a most important coaling station.

*Opening address by Colonel Sir Francis de Winton, K.C.M.G., F.R.G.S., President of Section E, British Association, Newcastle, 1889.

AUSTRALIA.

From the isles of the Pacific it is but a step to Australia, with its six great colonies of Queensland, Victoria, New South Wales, South Australia, Western Australia, and Tasmania, to which may be added New Zealand. Virgin fields untrodden by the foot of the white man are still awaiting the explorer to yield up their treasures to the science of applied geography; and when the marvelous progress that has been made in a few short years by our Australian colonies is weighed and considered, and as its vast interior is opened by exploration, and its mineral resources are developed, who could venture to predict the future that lies before it?

There are now nearly eleven thousand miles of railway in operation, and many more miles are in course of construction throughout these various colonies—a sure and certain indication of their energy, wealth, material prosperity, and progress. Geographically speaking, some are not without their troubles. Take Queensland, for instance. Her territory runs north and south for nearly 1,500 miles, and lies both in the temperate and tropic zones. The governments who during past years have administered her affairs have experienced some difficulties while endeavoring to reconcile the conflicting interests which arise out of her geographical position.

Laws relating to labor and capital in a temperate zone are not always in conformity with the industries and requirements of a tropical temperature, in which the white man is obliged to employ labor suitable to the climate. Hence we find a numerous section of the inhabitants of the northern part of this colony agitating in favor of separation. Australia has large coal measures, and abounds in precious metals as yet hardly developed.

Attached to Australia are the great and lesser islands forming the Australasian archipelago. The most important of these is New Guinea, and quite recently a successful exploration of its highest mountain range has been accomplished by the present administrator, Mr. McGregor, who reached an elevation of about 14,000 ft. A very interesting paper was read before the Royal Geographical Society by Mr. Paul Thomson concerning the D'Entrecasteaux and Louisiade groups, adjacent to New Guinea; and though many of these islands and their inhabitants are quite new to us, still the knowledge we gain from a study of their geographical position may be turned to practical uses by the merchant adventurer.

AFRICA.

Last, but not least, in this record of geographical progress of the world is the vast continent of Africa.

As General Strachey, late President of the Royal Geographical Society, in his address of this year, remarks:

"The reflection can hardly be avoided that, great as has been the advance of exploration in Africa during the last twenty or thirty years, the interest of geographers will, in the immediate future, be more and more centered in that continent. Excluding the polar regions, there is no considerable portion of the earth's surface, unless it is in Africa, the essential outlines of which have not been delineated."

These words are, I think, absolutely true. Whether we consider Africa in regard to the extraordinary explorations and developments since the commencement of the work of David Livingstone, or from the fact that vast areas of its tropical portion remain untouched as yet by exploration, and are, therefore, unknown, or from a contemplation of the teeming millions of its inhabitants, of which the larger portion have never seen a white man, or from the uncompleted work of the late General Gordon, and the re-establishment of the power of a civilized government over the whole of the Nile basin, or from the slavery question, in which our nation has taken the most active and leading part, or from the spectacle of a white man, Emin Pasha, establishing a settled form of government in the heart of the continent, between the two great slave dealing communities of the Bahr-el-Ghazal and that of the Upper Congo and Lake Tanganyika, or from the expedition sent to convey to him the succor he so much needs, under the leadership of Mr. H. M. Stanley, or from the intense interest recently exhibited by the nations of Europe in portioning out Africa between each other—an interest that has led on the west coast to the establishment of the Congo Free State, and the German protectorate in the Cameroons, France and Portugal adding largely to the possessions they already hold, and England contenting herself with strengthening her grip upon the Niger, and on the east coast by the formation of the British and German spheres of influence—or to the colonies which Great Britain possesses in the southern extremity of this great continent, or to the struggle which, sooner or later must be fought out between Christianity and Mohammedanism as regards the native races of Central Africa, in which the River Congo will play an important part.

I say when we consider all these and the many other problems of this continent, the vast interests they represent, and the varied influences they may yet exert on the future history of this earth, as well as the extraordinary part which Great Britain has been permitted to play in lifting the veil of mystery and doubt which up to our own times enveloped these regions, we are forced to acknowledge that the country in which the civilized world takes the most active and absorbing interest is Africa, and that the Dark Continent still maintains its supremacy.

As regards Africa, two very remarkable journeys have recently been brought to a successful conclusion—that of Count Teleki, an Austrian, on the north, and that of Mr. Arnot in the regions south of the equator.

The former, entering Africa at Mombasa, at the head of a numerous and well equipped caravan, passed through the Masai country by what is known as Thompson's route, and, pushing northward, discovered Lake Rudolph, a large inland salt lake, and by following its shores he was enabled to trace with commendable accuracy its shape, size, and position. The existence of a large lake, called Samburu, in the direction of Count Teleki's journey, had for some time been spoken of by the Arabs who traded in that region, but nothing definite was known concerning it. Count Teleki also obtained much valuable information of the region between Mount Kenia and Lake Rudolph, its inhabitants, its rivers, and its products, and the details of his most interesting and successful journey have yet to be published.

Mr. Arnot, on the other hand, started in 1883 from Pietermaritzburg with a very slender equipment and hardly any following. His object was to prove the existence of healthy plateaus in the interior of Africa, where white men could live and prosecute the work of missionary civilization without being exposed to the malarial influences which exist in so many parts of central Africa.

Taking a northerly course, he reaches the Zambesi, whose waters he follows as far as Lealui. From this point his route trends to the west as far as Robongo, the capital of the Bihe country. From Robongo he continues his march to Bailundu, and from thence he reaches Benguela, on the west coast. Thus he crossed Africa in the same direction as Livingstone's first journey, though somewhat to the south of Livingtone's route. While at Bailundu he meets some messengers from Msidi, the chief of the Garangenze country, who beseech him to visit their king; and, having replenished his stores, he retraces his steps to the interior.

From January, 1885, to February, 1886, he perseveres in his attempt to reach the capital of Msidi's country, and his efforts are at length crowned with success. After a sojourn among these people for two years, during which time he thoroughly succeeded in obtaining their confidence and that of their ruler Msidi, he returned to Europe in the latter part of last year, but not before he had established two other white missionaries at Mukururu to continue the work he had begun.

He also made several small expeditions during his residence at Mukururu, the most interesting of which was to the cave dwellers of Urua, mentioned by Livingstone. This kingdom of Garangenze is situated to the east of Lake Moero, and Mr. Arnot has recently published a book of his travels, giving a very clear and interesting account of these people, their manners, and their customs. Of all Livingstone's followers, Mr. Arnot very closely resembles the great leader in the patient earnestness, the quiet energy, and the scanty resources with which he prosecuted his remarkable journeys.

He has quite recently returned to the west coast of Africa, with the intention of rejoining his friends at Garangenze.

The events which attended the expedition under Mr. H. M. Stanley to succor and relieve Emin Pasha are so well known to you all that I shall only attempt a brief recapitulation here.

We have learned from his own pen how, after much suffering and great hardships, he eventually overcame all the difficulties and obstacles which had to be encountered while conducting his caravan from the head waters of the Congo to the lake Albert Nyanza; that on reaching that lake he met Emin Pasha.

The value of Mr. Stanley's journey and the remarkable energy and courage he displayed, his high scientific attainments, and the information that will result from his labors, are, from a geographical point of view, of the highest interest. The desiccation of the lake Albert Nyanza, and its influences on the rise and fall of the Nile, are not the least remarkable of these problems. For my own part, I am of opinion that this rise and fall is mainly caused by the rapid growth of tropical water plants. During the dry season this vegetation increases enormously, and at the first rains large masses of aquatic growth are loosened by the rising of the waters. These masses, in the form of floating islands, pass downward on the bosom of the flowing waters, and on reaching a wide and shallow part of the river, such as we find at the Bahr-el-Ghazal, they gradually but quickly collect till they form a dam of sufficient density to obstruct the progress of the river; and the water thus arrested finds a temporary lodgment in the lake Albert Nyanza, causing it to overflow its normal boundaries. At length the vegetable dam can no longer withstand the weight and pressure of the water bearing upon it; a portion gives way; a channel is opened; and the river, hurrying on to the sea, overflows the banks of the Lower Nile and drains the lake to a lower level. This is what happens to the Albert Nyanza, which is nothing more than a huge backwater of the Upper Nile basin, and it accounts for the lake being seen at two different levels by those two distinguished explorers Mr. H. M. Stanley and Sir Samuel Baker, and hence the difference of opinion as to its true extent and size that has arisen between them. We know that this phenomenon takes place on Lake Tanganyika, as Stanley found a marked difference in its level on the two occasions he rested upon its shores.

He also followed the Lukuga River from the Tanganyika Lake to its junction with the Congo; and there is no doubt that a vegetable dam, such as I have described, forms at the point of departure of this river from the lake, and prevents its regular flow till the weight and pressure behind it sweeps all away. During the second year that I was on the Congo we had an unusually heavy flood at the time of the first rains. The river rose several feet in one night, and some months afterward news came from the Upper Congo that the waters of the big lake had broken through, and this no doubt had reference to the Lukuga River and Lake Tanganyika.

Now, as regards the countries through which we have been passing, there are certain points of great interest connected with the science of applied geography to which I desire to draw your special attention.

The first of these points is the study of the great railway systems of the world, and the application of railways to the development of new countries. Take our Indian possessions for example. What a change has been wrought not only as regards the commerce of the country, but also with reference to the social condition of its inhabitants and their manners and customs! The introduction of Indian wheat, by means of these railways, into the markets of Europe has caused a revolution in the trade in that commodity. We find this especially in America, where it has upset the calculations of those gigantic combinations or rings which sought to obtain a monopoly in the supply of this universal article of food. Thus the construction of railways in the East exercises commanding influences over the markets of the West.

Consider also the traffic from China and Japan to America, with its 60,000,000 people, by means of the great Atlantic and Pacific railways, in tea and raw materials. Now, although railways cannot compete with a direct traffic by sea, when the necessity for more rapid conveyance of certain goods arises, we find that a combination of sea and land transport is often adopted in preference to the longer route by sea alone.

The development of any country, no matter what its geographical position may be, is enormously increased by the construction of railways. Take the Congo Free State as an instance (which is undoubtedly the finest property in Central Africa). So long as the Upper Congo region, with its miles—measured by thousands—of navigable tributaries, was separated from the Lower Congo by the rapids extending from Stanley Pool to Matadi, this magnificent territory was practically shut to trade and commerce. Every piece of goods in the interior had to be carried on men's heads for more than 200 miles, and all ivory and other products were brought to the coast in the same way. Roughly speaking, such transport costs about £40 per ton.

The Congo Free State has wisely determined to build a railway, of some 250 miles in length, to cross this cataract region; and the moment it is completed, the future of that country is assured.

H. M. the King of the Belgians has kindly given permission for a Belgian officer of distinction, Captain Thys, to read a paper at this meeting on this railway, which will afford a more detailed account of this wise and patriotic undertaking.

I have mentioned railways as the first point of interest because they are creations of our own time, and have therefore a special interest of their own; but the most important factor in the early history of the science of applied geography, and to which the establishment of our great colonial empire is mainly due, is the record of the merchant adventurers.

Their voyages and exploits, extending to every part of the globe, began at the end of the fourteenth century, in the reign of Henry VIII., when the Cabots (Venetians) sailed from England to Newfoundland, and afterward to Florida. This expedition and those which followed it were fitted out at the expense of corporations of merchants, with the object of extending the commerce of the country by a search after trade in new and foreign lands. They were placed under the command of some well-known leader, and the results obtained were extraordinary.

In 1530 the merchant adventurers of England attempted the Northwest Passage, as it is called, to China, and between 1550 and 1578, Sir H. Willoughby, Frobisher, and Sir H. Gibbon all made remarkable voyages.

Between 1585 and 1615, Davis, Hudson, and Baffin were sent by merchant companies to the polar seas, and their discoveries are handed down by the straits and bays which they discovered, and which bear their names.

In 1580 Drake took the first English vessels into the Pacific Ocean. Drake was not only a bold and successful navigator, but he was also a commander of men, in which he showed rare tact and ability.

In 1588 the merchants of Exeter established a trade with the West African coast, and the Senegal Company was formed.

In 1553 the first effort to reach India was made *via* the Cape of Good Hope. It was not, however, till the year 1660 that any progress was made in the East. In that year the East India Company was formed, and it is to the establishment of this company that we owe our great Indian empire. The year 1669 saw the formation of the Hudson Bay Company—a company which exists at the present day. And so the record goes on down to our own times. Not the least among the trading corporations of Great Britain were the merchant adventurers of this city in which we are now assembled; and they, too, contributed in no small degree, not only in the past but in the present, to the extension of our geographical knowledge and its application as a science. No doubt the spirit and energy of our Scandinavian forefathers has been fostered and encouraged until it has now found its development in the enterprise and prosperity of this great mercantile center of the north of England. And the old churches of Jarrow and Monkwearmouth bear further testimony to the fact that, as commerce drew together communities which became centers of maritime energy and progress, religion was not forgotten, and the seed of knowledge and truth thus sown in the early history of the past has spread itself throughout the length and breadth of the great colonial empire of Greater Britain.

Following on the discoveries of the sixteenth and seventeenth centuries, and the marvelous results to which they have given birth, the story of our own times, from a geographical point of view, is quite as wonderful. As I remarked at the beginning of this paper, the discovery of steam as a motive power has brought the world into an extraordinary condition of contactiveness, and quite recently several new companies have been formed in the same spirit and on the same lines as those followed by the old merchant adventurers. These latter creations are being started under more favorable conditions than their predecessors, for they have all the advantages which modern science and modern appliances can afford. The English government have wisely encouraged and promoted the formation of these trading corporations. In countries where climate and circumstances of environment are not favorable to colonization by white men, our colonial system of government progresses somewhat slowly. It has not the elasticity, nor the adaptability, to provide for the many contingencies which must naturally arise when a few white men maintain the position of rulers over large areas peopled by savage and uncivilized races.

In the island of Borneo there is the North Borneo Company trading, governing, and civilizing a large portion of territory with marked success.

On the west coast of Africa, the Royal Niger Company is developing the great natural resources of that magnificent river and its tributary the Binue.

On the east coast there is the Imperial British East African Company, operating in what is known as the British sphere of influence north of Zanzibar. Though not a twelvemonth has passed since they commenced their work, their initiatory proceedings have been remarkably successful, and there is every prospect of an early and rapid development of the territory committed to their charge. In the southeastern portion of Central Africa, the African Lakes Company have fairly established themselves; and a new company is now being formed to open up and civilize a further portion of that section of the African continent.

The establishing of these great trading and governing centers is likely to exercise most important influences. They are, as I have before pointed out, from their organization and objects, better adapted at the outset to compete with and overcome the obstacles which present themselves to established forms of bureaucratic government; at the same time the government of this country can interfere in cases of necessity, by the grants that have been made to them of royal charters, under which they carry on their operations.

A wise control and judicious administration combined with the introduction of commerce and civilization will at no distant date open these territories to the markets of the world, to the missionary, and to the scientific explorer. The commercial element of geography also enters very largely into their promotion and prosperity because of the fields they open to our home manufactures. It is important here to observe that, if these territories had passed into the hands of other nationalities, but a very limited quantity of British goods would ever have entered into them, and their value, as a market for the industries of the nation, would have been lost.

The establishment of a geographical society in this city is of real importance. Its objects should be the collection of information and the study of applied geography in all its varied branches and aspects. It should aim to furnish complete information concerning the geography of all parts of the globe. In chambers of commerce our large trade centers have, no doubt, means of guiding and controlling some of our most important mercantile operations, but they afford no opportunities to the student, they are not teaching bodies; and there are instances where considerable risks have been incurred and heavy losses sustained in some of their ventures, simply from a want of knowledge of geographical data.

I should like to see a geographical society in every large city of this empire, conducted on the lines I have briefly suggested, because the study of, and interest in, the commercial geography of this great empire and the world is too much neglected among us. Past prosperity, and a tendency to run in the same groove, narrow our commercial horizon. Slowly but surely other nations, competing with us in many parts of the world, are doing so successfully because of the study they make of commercial geography.

It is for this reason I have in my address dwelt strongly upon the question and study of geography as an applied science, and it is for a greater reason I urge its importance, viz., that we may hand down to our children unimpaired the heritage bequeathed us by our forefathers; a heritage gained by courage, energy, perseverance, and patriotism—qualities which, under God's blessing, have made this nation the head of the commerce of the world.

THE CHEMICAL PAPERS AT THE BRITISH ASSOCIATION.

Owing, doubtless, to the numerous chemical industries of the district, many of the papers read in Section B, at Newcastle, were of special interest to the technical student.

The president's address on "The Metallurgy of Iron" was followed by the report of the committee for investigating the influence of silicon on the properties of steel. From the results of Mr. Hadfield's experiments, it appears that silicon by itself does not produce a steel that will harden by water quenching. The brittleness noticed in ordinary so-called silicon steel is due, not to silicon alone, but to the combined presence of the two hardeners, silicon and carbon. Silicon up to six per cent. does not destroy the malleability of iron, nor are the magnetic properties greatly affected by increasing percentages of silicon, as is the case with manganese steel.

The committee for establishing an international standard for the analysis of iron and steel reported that they had made good progress with the work, and hoped before long to have the necessary analyses completed.

Some curious experiments were described by Mr. J. W. Hogg, on the volatilization of lead oxide and its action upon glass at low temperatures. If some writing is placed upon a glass plate or platinum foil, using lead oxide as a pigment, if a polished plate of glass be placed over this as closely as possible and prevented from actual contact by suitable means, upon now heating up to scarcely visible redness, a distinct reverse of the design will appear upon the upper glass. The quantity of lead oxide which will produce this effect is not shown by the most delicate balance.

Photographers were interested in Prof. Liveing's account of a new developer, "Eikonogen," which appears to give greater detail than most of those now in use. The tone of the negative is also excellent. Eikonogen is the sodium salt of amido-β-naphthol-b-sulphonic acid.

Mr. C. T. Heycock and Mr. F. H. Neville read a paper on Raoult's method applied to alloys. Alloys of a number of metals with sodium and tin were studied. The "atomic fall" of the freezing point for aluminum was about half that of most other metals—pointing to twice the present number as the atomic weight of aluminum. Antimony produces a rise in the freezing point of the alloy, for some unexplained reason. Contrary to Raoult's so-called second law, it was found that the nature of the solvent is of influence; 1 atomic weight of metal in 100 atomic weights of sodium not giving the same fall as 1 in 100 of tin. The method would seem to give a means for correcting and verifying atomic weights, though it does not give much information as to the molecular weight. It was shown that, in accordance with Van't Hoff's theories on the nature of solution, each metal produces its own lowering of the freezing point in presence of others.

Prof. Bedson afterward gave an interesting description of Dr. Netto's process, at work on the Tyne, for the manufacture of aluminum from cryolite. The cryolite is first fused with salt in a reverberatory furnace, then run out into converters in which sodium is gradually added—about five pounds at a time. Sodium fluoride and metallic aluminum are formed. The sodium is obtained by allowing molten caustic soda to flow gradually on to charcoal contained in a cast iron retort heated to a dull redness. The sodium carbonate formed in the reaction sinks to the bottom of the retort. The greater concentration of the caustic soda thus produced enables the temperature to be kept lower than in the Castner process.

An account was afterward given, by Mr. J. H. I. Dagger, of the Cowles method for manufacturing aluminum alloys.

Dr. Richardson exhibited and described a new self-registering actinometer, based on the fact, discovered by Budde, that chlorine expands in the actinic rays, contracting again in the dark.

Prof. H. B. Dixon gave an account of experiments made by himself and Mr. J. A. Harker, on the explosion of a mixture of hydrogen, chlorine, and oxygen. It was found, in contradiction to previous statements, that steam is produced by the explosion even when chlorine is in excess. It was noted that hydrogen and chlorine, when exploded alone, give a sensible contraction.

In another paper the same workers show that hydrogen and chlorine do not explode when dry, unless exposed to very intense light.

Dr. A. P. Laurie gave some results of his researches on artists' colors. He is comparing the recipes given in the manuscripts of the old masters with those in modern use.

A new ferment was described in a paper by Prof. P. F. Frankland, Miss Grace F. Frankland, and Mr. J. J. Fox. From the products of its activity, ethyl alcohol and acetic acid, it is termed, *Bacillus ethaceticus*. It will cause a solution of mannite to ferment, while dulcite is unaffected by it.

In his paper on the constitution of the aromatic nucleus, Mr. S. A. Sworn gave preference to the octahedral formula of Thomsen. A further development of Thomsen's formula, he believes, affords a full explanation of the laws of para and meta substitution.

Dr. Isaac Ashe read a paper entitled "Dimidium: an attempt to represent the chemical elements by physical forms." He put forward the view that the primordial basis is to be found in an element having half the combining weight of hydrogen. This hypothetical element is named dimidium. The relations of attraction and repulsion under the influence of polar force suggest a linear form for such a body. A series of vortex rings, superposed one on the other, would yield a form elongated in one direction and limited in the other two. Having shown that the primordial element may have a bar-like form of definite length, the author proceeds to construct models of the different elements, conforming in each case to the combining weight, valency, crystalline form, etc.—*Nature*.

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